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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCAT
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NO. 1, JANUARY 1967

In the order listed, this issue contains articles on the following subjects:

IONOSPHERIC RESEARCH DURING A SOLAR ECLIPSE
A NEW ARMY LABORATORY NEAR THE U OF I
THE WORLD'S LARGEST ATOM SMASHER — IN ILLINOIS
THE APPOINTMENT OF A NEW ASSOCIATE DEAN
A SPECIAL PROGRAM FOR ENGINEERING TEACHERS
USING NATURAL PROCESSES TO PURIFY WATER

SHOTS IN THE DARK

A total eclipse of the sun in South America provided a high-speed test of changes in the ionosphere for University of Illinois scientists November 12. The change from daylight to dark and back, which occurred in one minute as the eclipse began and ended, takes an hour at normal times.

Under the leadership of Electrical Engineering Professor Sidney A. Bowhill, scientists used the speed of these changes to study how quickly "piggyback electrons" attach themselves to molecules in the dark and how quickly they are freed by the sun. These electrons play a major role in the behavior of invisible clouds which reduce the range of radio reception in daylight hours.

Four rockets carried U of I instruments 100 miles into the sky to report events as the moon's shadow blocked off the sun. The launch site was on the Atlantic coast 100 miles north of Buenos Aires. The project was sponsored by the National Aeronautics and Space Administration as part of a $261,421 grant, in cooperation with the Brazilian Space Commission.

Probing of the ionosphere with rocket-carried instruments will continue: In addition to the grant for research directed by Professor Bowhill, a sum of $39,153 has been provided for development by Professor Charles D. Hendricks, Jr., of a mass spectrometer for use in this research.

Three other projects will be supported by these grants. Data gathered by rocket will be compared with those from a giant radar antenna at Arecibo, Puerto Rico, in March or April. The ionizing effect of chemical changes when warm air breaks into the winter circulation of cold polar air high overhead will be explored by rockets scheduled for launching in February. Theories about this phenomenon have been developed by Professor Chalmers F. Sechrist at Illinois. Hendricks' mass spectrometer will be used to study the effect of meteor dust on the ionosphere. These projects are part of a broad area of ionospheric research in which the University of Illinois has gained international renown. ◆

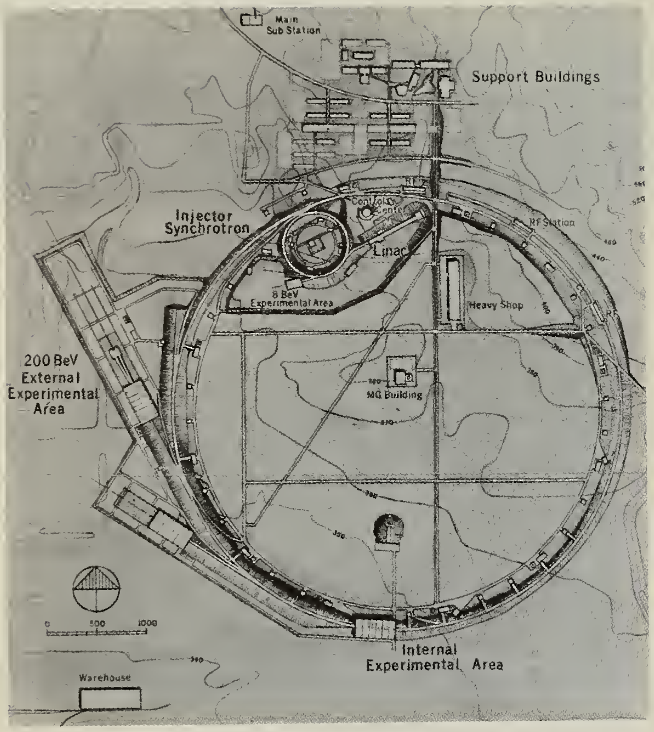
UNIVERSITY AREA TO GET NEW ARMY LABORATORY

The Corps of Engineers has selected Champaign-Urbana and the University of Illinois as the site of its new multimillion dollar Construction Engineering Research Laboratory. Located north of Champaign at the Interstate Research Park, the first of the laboratory's three building stages should be completed in mid-1968. Estimated at a total cost of $7.1 million, the laboratory will, over the next several years, employ 250 or more persons and have an annual budget of $3.5 million.

The U of I was selected after a study of proposals submitted by twenty universities in response to an invitation by the Corps of Engineers, according to Lieutenant General W. F. Cassidy, Chief of the Army Engineers. The Corps sought proximity to an outstanding university where cooperative working arrangements could be established and where strong programs and graduate study in research existed. The distinguished reputation of the College of Engineering and the Civil Engineering Department were important factors in selecting a site near the University of Illinois.

The Construction Engineering Research Laboratory will be concerned with finding ways to speed the application of the latest construction technology, more progressive construction policies, and methods of developing and expediting long-range research programs.

Mr. H. O. Farber, vice-president and comptroller of the University of Illinois, and Professor N. M. Newmark, head of the Department of Civil Engineering, will represent the U of I in planning for the laboratory. ◆



The Atomic Energy Commission has selected a site near Weston, Illinois, for the construction of a giant 200-billion-electron-volt particle accelerator. The ring of the synchrotron will be nearly a mile in diameter. University of Illinois physicists will have useful access to what will be the largest atom smasher in the world.

POSITIVELY SMASHING

University of Illinois physicists are among those most pleased over the Atomic Energy Commission's choice of Weston, Illinois, as the site of a new atom smasher, which will be the largest in the world. "We are delighted, first of all, that the machine has come to the Midwest and especially gratified that it has come to Illinois," said Professor Gerald M. Almy, head of the U of I Physics Department. "It is a national machine and its success will depend on its national use. We have the advantage of being close by."

The new device, which will accelerate protons to energies of 200 billion electron volts, "will extend the energy range of particle physics by a factor of 10 and expose a whole new world of nuclear phenomena," according to Almy. The circular course in which the particles are accelerated will be nearly a mile in diameter. Electromagnets arranged in this circle will speed the protons — positively charged particles which help compose atoms — to speeds almost as fast as light. Then the protons will be shunted from the three-mile track to collide with targets arranged so that the effects of the collision can be recorded by special photographic equipment.

The purpose of the whole mind-stunning business is to find the fundamental building blocks of matter, and to understand what sticks them together. A vital question concerns the existence of "quarks," hypothesized but still-undiscovered subatomic particles being sought at Illinois (see the October issue of *Outlook*).

The accelerator, called a synchrotron, is predicted to be the most costly scientific installation ever built: It will cost $300,000,000 to build and $60,000,000 annually to operate.

Illinois physicists, internationally known for their work in high-energy physics, are not the only University personnel associated with the synchrotron. University experts in such fields as geology and civil engineering worked with teams from the State Water Survey and other institutions to provide the AEC with information about the Weston site's suitability for the accelerator.

In making its announcement of the Illinois choice for the site of the synchrotron, the Atomic Energy Commission described the machine as "the biggest and most complex instrument ever built for fundamental scientific research, which will lead to a deeper understanding of the basic forces that govern the universe." ◆

WAKELAND NAMED ASSOCIATE DEAN

Dean William L. Everitt of the University of Illinois College of Engineering has announced the appointment of Howard L. Wakeland as Associate Dean of the College. Wakeland, who has served as Assistant Dean for 12 years, fills a post left vacant by the death of Stanley H. Pierce on October 30.

Wakeland graduated from the University's Department of Agricultural Engineering in 1950, and in 1954 earned his master's degree from the same department. His activities as Assistant Dean have brought him close contact with and especially high regard among the College's students. ◆

SUCCESS OF TEACHER INTERNSHIP PROGRAM ANNOUNCED

The final report to the sponsors of a special four-year pilot internship program at the University of Illinois indicates impressive success. The report, issued by Mechanical and Industrial Engineering Department associate head Seichi Konzo, describes the Engineering Teacher Internship Program in Electrical and Mechanical Engineering. The project involved a group of graduating college seniors who expressed interest in careers as engineering teachers. Those selected for the program studied under experienced teachers for two years, after which time they entered the master's and doctoral degree program. After receiving their advanced degrees, they were to enter the teaching profession at other universities.

Sponsored by a $207,000 grant from the Ford Foundation, the pilot program began in September, 1959, and ended in June, 1964. Thirty-four men were chosen for the program, and only seven dropped out after completing their master's degree studies. Twenty-seven are still working toward or have completed their doctoral programs. Eleven of the twelve who obtained their Ph.D. degrees have accepted teaching assignments in this country and in Canada.

In citing this "remarkable record," Engineering College Dean William L. Everitt noted that "the University of Illinois has gained much from this pilot program. One of the lessons learned has been that a guidance and orientation program for all teaching assistants in the College is necessary and worthwhile." ◆

MORE COURSE FREEDOM FOR ENGINEERING STUDENTS

In the future, University of Illinois engineering students will be free to choose six hours of electives in any courses offered by the University except physical education and remedial courses. Details of the new arrangement are being worked out in the various engineering departments, according to David R. Opperman, assistant dean of the College of Engineering.

Presently, engineering students must have from 130 to 142 hours to graduate. Of these a minimum of 18 hours must be in social sciences and humanities; the remainder are in technical subjects. The six hours of electives, recommended by the Student-Faculty Liaison Committee and approved by the faculty this fall, will go into effect in September, 1967, for students enrolling on or after that date. ◆

CLEANING WATER WITH AIR

No matter how fresh and pure a glass of water looks, chances are it's been used before — perhaps many times — since it fell somewhere as rain. The growing concern for reuse of water makes it easy to forget that this process has been going on for years. Town B, for example, is reusing water when it takes its water supply from a river into which Town A upstream has dumped its waste water.

Town B normally depends on at least three processes to make the water suitable for reuse: treatment of Town A's wastes before they are put into the river, natural purification as the water and wastes flow downstream, and final treatment by Town B itself. Natural purification, of course, costs neither town anything. As this natural process is used more effectively, the cost of reusing the water decreases.

Natural purification depends largely on the presence of dissolved oxygen in the water. Waste material feeds on this oxygen and purifies itself. A major source of dissolved oxygen is reaeration — absorption of oxygen from the atmosphere — and turbulence in the water exerts a strong influence on how much oxygen can be absorbed.

At the University of Illinois, Civil Engineering Professor E. R. Holley is looking at just how turbulence influences reaeration. His study, sponsored by the Office of Water Resources Research, uses heat as a tracer to follow the way in which turbulence distributes absorbed oxygen throughout the water.

Holley also plans to measure directly the turbulence of the water, in order to learn more about how dissolved oxygen is moved away from the water's surface to be consumed by the waste material and make room for more oxygen from the atmosphere. He hopes that his work will enable engineers to use natural purification more efficiently, by knowing the effect of turbulence. A punster might even say that Holley is stirred up about the idea. ◆

BULLETINS DESCRIBE BRIDGE BEHAVIOR

Highway bridge impact is the subject of a new Engineering Experiment Station publication. Bulletin No. 489, *Response of Three-Span Continuous Highway Bridges to Moving Vehicles,* by J. A. Nieto-Ramirez and A. S. Veletsos, provides insight into the dynamic behavior of continuous highway bridges under moving vehicles. Bulletin No. 489 is the second of three closely related studies in this area of highway bridge dynamics. The first is Bulletin No. 486, *Response of Simple-Span Highway Bridges to Moving Vehicles,* by W. H. Walker and A. S. Veletsos. The third bulletin will be published next year. Bulletin No. 489 ($3.00) and Bulletin No. 486 ($4.00) are available from the Engineering Publications Office. ◆

WATCH

The growing world of shrinking hardware is profoundly affecting one of the oldest and proudest professions — that of watchmaking. As mechanical and electronic devices grow smaller and smaller, the need for technicians skilled in horological and micro-precision work has become critical.

In response to this shortage the University of Illinois, supported by a $188,000 grant from the U.S. Office of Education, has begun a one-year program of planning a curriculum and training an initial class of 60 students in these skills. Director of the project is Professor Jerry S. Dobrovolny, head of the Department of General Engineering. Marketing Professor Hugh G. Wales of the College of Commerce and Business Administration is the project supervisor. ◆

ENGINEERS' WAGES UP 162 PER CENT IN TEN YEARS

The first income survey of engineering alumni ten years after graduation has been reported by Mrs. Pauline V. Chapman, Placement Director of the College of Engineering. Data were obtained from 392 of 592 seniors who received bachelor's degrees from the College in 1956. Income for the average engineer in the group increased 162 per cent, from an average starting salary of $435.75 per month in 1956, to $1,142.59 per month now.

Five members of the class receive more than $2,000, the top receiving $2,500. The 279 with bachelor's degrees average $1,104.51; the 69 with Master of Science degrees, $1,201.05, and the 23 with the Doctor of Philosophy degrees, $1,301.17. In addition, 14 with the Master of Business Administration degrees average $1,202.64, and four with the degree Bachelor of Laws, $1,660.00. Thirty-eight per cent had their first jobs in Illinois, and ten years later 37 per cent are working in the state. Thirty-six per cent are with the same employer with whom they started ten years ago. ◆

PEOPLE AND PLACES

Professor **Clyde E. Kesler** has been nominated for president of the American Concrete Institute. This is the world's leading organization dealing wholly with concrete and has members in 107 countries. Nomination for the office of president is equivalent to election.

Kesler, a professor in both the Civil Engineering and Theoretical and Applied Mechanics Departments, has served the Institute as vice-president for two years and will move to the top post at the organization's meeting next April in Toronto, Canada. At age forty-four he will be the youngest president in more than 30 years.

William C. Ackerman, chief of the Illinois State Water Survey and Professor of Civil Engineering, has been named president of the American Geophysical Union, a society concerned with all aspects of the geophysical sciences. He has been vice-president of the Union, and is past president of its hydrology section. The AGU's geophysical interests relate not only to the land and water surfaces of the earth, but also to the atmosphere and space beyond.

Recently elected to the board of directors of the American Society for Quality Control is Professor **John A. Henry** of the University of Illinois Department of Mechanical and Industrial Engineering. The post marks a long participation in the Society's activities, including association as a charter member and Fellow of the Society.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NO. 2, FEBRUARY 1967

This month marks the beginning of a proud occasion for the University of Illinois — the 100th year in the evolution of an institution that began as the collegiate equivalent of a one-room schoolhouse. *Outlook*'s part in this year-long birthday will be to announce events planned for the centennial through a new "Centennial Calendar" feature, report these events as they occur, and preview publications and other matters of interest. This issue features the first Centennial Calendar, on page 4. A preliminary survey of centennial events is presented here. In subsequent issues, the Calendar will concern events planned for the few weeks ahead, with further details of time and location. Most of the events will be open to the public. In total, this centennial year promises to be an especially rich one for University engineers. ◆

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1867-1967: A Century of Engineering at Illinois

The remnants of blue and gray uniforms still flavored the apparel of Illinois farmers and townspeople when a big, solitary, ugly brick building in the fields between the villages of Champaign and Urbana became the home of the Illinois Industrial University.

The label "cow college" was perfectly appropriate. Farmland and pasture stretched from horizon to horizon, and the University's first students—77 of them—had to build a fence to keep cattle off the campus.

Among the school's academic goals was the study of the "mechanic arts." For a tuition fee of $15 per semester the students could imbibe the secrets of these "arts," including such subjects as Butler's analogy, penmanship, evidences of christianity, history of inductive sciences, and elocution.

By 1880 the mechanic arts had grown into the College of Engineering, and five years later the Illinois Industrial University became the University of Illinois. There was no engineering graduate program and no research. The University saw as its purpose the dissemination of time-proven facts, not the discovery of new ones.

The turn of the century, however, found men at Illinois whose interest and talent in research had softened the University's conservatism. Because of their interest the University formed its Engineering Experiment Station, the first in the nation, in 1903. Throughout the next two decades, startling progress in science influenced engineering and the College.

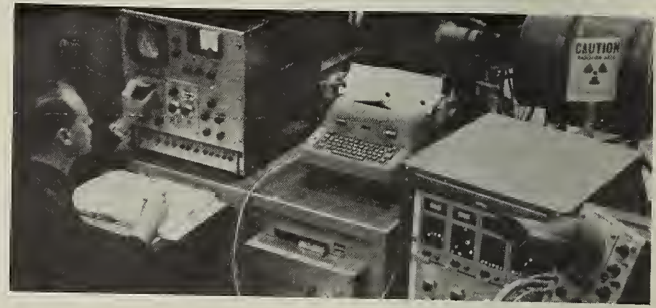
World War I and the impact of such technological innovations as aerial, submarine, and chemical warfare increased the world's awareness of the importance of engineering and engineering education. After the war, as a result, research which emphasized testing and applications was augmented by more fundamental, creative studies.

The effect of World War II upon technology and research was equally profound. Groups of men from different fields were assembled in large government laboratories to work on sophisticated new weapons like the atom bomb, proximity fuses, and radar. When the war ended, proponents of the interdisciplinary team approach urged that it be continued in peacetime research at universities. At Illinois such attitudes resulted in the creation of such groups as the Digital Computer, Control Systems, and Biophysical Research Laboratories.

The College of Engineering had changed with the times.

There were years before the turn of the century when engineering brought the University less attention than such local—and colorful—institutions as the Guitar and Mandolin Society, and organized tugs-of-war which left the losers in the mud of Boneyard Creek. A hundred years later the University's fame stemmed from more appropriate accomplishments, especially in engineering: *Industrial Research* magazine identified Illinois as one of the nation's "centers of excellence" in science education; *An Assessment of Quality in Graduate Education,* a study published by the American Council on Education, included the U of I among the top five American universities in engineering; and national surveys repeatedly found the University among the leaders in volume of research and number of engineering degrees granted.

The changes in the nature of engineering research over the century were paralleled by changes in the educational programs. When engineering research was "applied," so was engineering education; when research assumed a more basic character, the change was likewise felt in the classroom; and with the modern trend toward interdisciplinary research, there has been a trend toward the education of engineers to work in fields that cross the boundaries of technical areas established by tradition and past practice. The cow college "mechanic arts" student has become, in a century, an almost completely different kind of man, required to meet and use the unexpected.



POPULAR BULLETINS REPRINTED

Two Engineering Experiment Station Bulletins, whose popularity had exhausted the original supply, have been reprinted and are again available. Bulletin 212, *Stresses Due to the Pressure of One Elastic Solid upon Another,* and Bulletin 332, *Analyses of Skew Slabs,* are available from the Engineering Publications Office for one dollar each. ◆

IT WON'T CRACK WHEN THE HEAT'S ON

Ceramic engineers at the University of Illinois have come up with a gem of an approach to a problem which has plagued the steel casting industry for several years. Magnesium aluminate spinel, which in some forms is a semiprecious gem stone, has been found to be an excellent refractory material capable of enduring the tremendous heat and corrosion inherent to the controlled pressure pouring process.

This process, developed and used by the Griffin Wheel Company — a subsidiary of AMSTED Industries — to manufacture steel railroad wheels since 1951, was adapted to the commercial casting of stainless steel slabs in 1964. The process involves forcing molten steel under pressure through a ceramic tube into a graphite mold.

Because of the alloying constituents in stainless steels, the refractory tubes are subject to great chemical corrosion. Even though the temperatures involved are comparable, the tubes used in slab casting are much larger than those for wheels. This imposes additional problems related to high temperature strength and thermal shock resistance.

Research Associate Professor T. A. Willmore and his colleagues have produced special refractories for the tubes by firing pressure-formed spinel-base mixtures at high temperatures. Their tests, conducted in the Department of Ceramic Engineering, indicate that this class of refractory materials can withstand the severe conditions imposed by the pressure pouring process. They hope to verify their conclusions in pilot plant tests conducted by the project sponsor, AMSTED Research Laboratories. They may show that the ceramic engineers' best friend is not diamonds, but spinel. ◆

LUCKY 13

Thirteen University of Illinois students ended their Christmas holiday a half-day early to make a field trip to St. Louis as part of an engineering honors course. The class flew to Lambert Field on January 3 and unloaded there, at the door of McDonnell Aircraft Company, for the day-long tour.

The interdisciplinary course on space vehicle design is being taken by James Scholars in Engineering from the Departments of Physics, Mechanical Engineering, Aeronautical and Astronautical Engineering, and Electrical Engineering. Professor J. O. Kopplin of the Department of Electrical Engineering and Professor A. I. Ormsbee of the Department of Aeronautical and Astronautical Engineering are in charge. ◆

FLUID DYNAMICS RESEARCH REVIEW

The first Fluid Dynamics Research Review to be held at the University of Illinois has been announced for March 6 and 7. The program is planned for industrial engineers who want to keep up with developments affecting fields ranging from aircraft and missiles to machinery for handling gases or liquids.

Seven departments of the University's College of Engineering are presenting the two-day program under the auspices of the Engineering Experiment Station. Reports will cover work in areas from low to supersonic velocities.

Speakers will represent the University of Illinois in mechanical and industrial engineering, aeronautical and astronautical engineering, chemical engineering, civil engineering, electrical engineering, nuclear engineering, and theoretical and applied mechanics. The program is similar in its field to the University's Annual Review of Electronics, the fourth of which was held recently. The meeting will include tours through laboratories of the seven engineering departments involved. ◆

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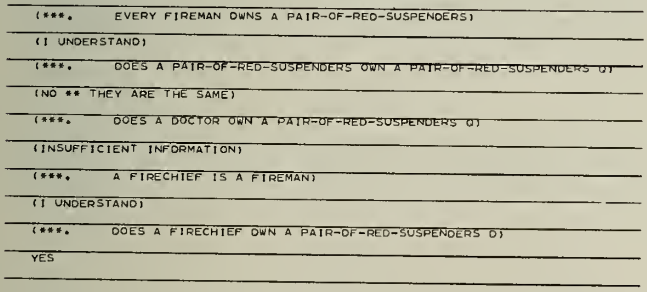

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Although this exchange between a man and a computer will probably never make the pages of Bartlett's *Familiar Quotations*, most people consider it significant that a computer can carry on a conversation at all. At least one University of Illinois engineer expects more. Research assistant Paul Weston of the Electrical Engineering Department feels that the limited capacity of the computer to recognize vocabulary and sentence structure restricts its value as an engineering tool. He believes that by programming it with a knowledge of a few basic characteristics of language, plus the ability to associate messages with concepts, a computer can be made to judge and improve its own linguistic performance.

This effort requires, as one step, establishing the manner in which concepts are actually used by speakers of natural languages. Weston has begun his research by examining relationships among noun meanings.

A sample of over three hundred English nouns was analyzed and categorized in terms of the words' dictionary definitions. Weston found that each noun was defined by another noun of more general meaning, which was in turn defined by another noun of ever-broadening scope. This process continued until the definition referred back to a noun previously cited or until the concept grew so broad that it was necessary to define it with a noun phrase. The results showed that the average number of levels of definition was three, although some words had as few as one and others as many as six.

A computer analysis of the findings indicated that the frequency of the various levels of definition formed a bell curve. Studies on smaller samples of French and German nouns showed the French noun structure to be almost identical to the English. The German structure was somewhat more complex, and a more elongated frequency curve resulted because some German nouns have as many as eight levels of definition.

While Weston has found the simplicity and invariance of the noun definition results "encouraging," the study will have to be extended to include the much richer relationships among the remaining parts of speech and their comparison among languages. An understanding of these relationships, and their incorporation into the logic of the computer, will be a step toward the development of a really articulate machine. ◆

ENGINEERS MEET FOR ANTENNA FORUM

Two hundred electronics engineers from the United States and abroad met at the University of Illinois January 30 to February 3 for the second Forum on Electromagnetics and Antennas presented by the antenna laboratory of the Department of Electrical Engineering. Sixteen widely known speakers, of which nine were members of the Department faculty, presented an intensive two-day tutorial course covering fundamental electromagnetics and antenna theory and measurements. A three-day course on recent advances in electromagnetic theory and practices followed. ◆

FOURTH ACADEMIC YEAR INSTITUTE FOR ENGINEERING TECHNOLOGY TEACHERS

A grant of $129,140 has been received from the National Science Foundation to support the fourth Academic Year Institute for Engineering Technology Teachers. Professor Jerry S. Dobrovolny, head of the Department of General Engineering, is the Institute director. Under the grant, 15 teachers from junior colleges and technical institutes will come to the University of Illinois in 1967-68. This program, pioneered by the University, is planned to help meet an acute shortage of competent teachers of technology. The courses emphasize the application of basic sciences and methods of teaching. ◆

Centennial Calendar

Engineering Open House will feature a program, "Exploration of the Sea," on March 10 and 11, 1967.

A centennial lecture, "Political Problems in Implementing Engineering Decisions," will be given on April 6, 1967, by the Hon. Herbert Hollomon, Assistant Secretary of Commerce, U.S.A.

A book, *Men and Ideas in Engineering*, by R. A. Kingery, R. D. Berg, and E. H. Schillinger, will be published by the University Press in May. The book will describe the 100-year course of engineering at Illinois.

May 26, 1967, is the date scheduled for the dedication of the University's Materials Research Laboratory. Dr. Frederick Seitz, physics professor at the University of Illinois now on leave as president of the National Academy of Sciences, will be guest speaker.

The International Conference on Fundamental Research in Plain Concrete will be held at the University's Allerton House conference center at Monticello on September 5-8, 1967.

Undergraduate students in the College of Engineering will conduct a "Symposium on Engineering Education" on Tuesday, October 10, 1967.

A symposium, "Systems Studies of Transportation Problems," will be conducted by the Coordinated Science Laboratory. The dedication of the Laboratory's new building will be held on October 17-20, 1967.

The theme of the dedication of the new Civil Engineering Building on November 9 and 10, 1967, will be "A Look Ahead into the Next Century of Civil Engineering Education and Practice."

The engineering faculty will conduct a "Symposium on Engineering Education for the Future," on March 22 and 23, 1968.

A symposium on the topic "Information Retrieval" will be held at Illinois under the sponsorship of the BUILD Program with the University of Colorado. Ralph Phelps, Director, Engineering Societies Library, United Engineering Center, New York, will headline this program.

PEOPLE AND PLACES

The Allan P. Colburn Award winner for 1966 is **John A. Quinn**, Associate Professor of Chemical Engineering at the University of Illinois. The Award is given to encourage excellence in contributions to the publications of the American Institute of Chemical Engineers.

James W. Westwater, head of the U of I Department of Chemical Engineering, has also been honored. He has received the 1966 William H. Walker Award for his contributions to the literature of chemical engineering.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING . 8, NO. 3, MARCH 1967

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In the order listed, this issue contains articles on the following subjects:

UPPER-ATMOSPHERE RESEARCH
A RADIO STUDY OF THE SKY
UNDERGRADUATE RESEARCH FUNDS
A FLUID FLOW STUDY
CENTENNIAL CALENDAR

SKYLIGHT

A red, pre-dawn glow in the winter sky is under study by University of Illinois aeronomy researchers under Electrical Engineering Professor Sidney A. Bowhill. The phenomenon, called "airglow," takes place in the rarefied atmosphere 200 miles above the earth.

While some degree of airglow exists all night, a sudden increase occurs before dawn in the winter. This increase occurs simultaneously with sunrise in the corresponding latitude of the opposite hemisphere — north or south — which is enjoying its summer season. The precise time at which the airglow increase occurs is related to distance from the equator. The phenomenon is also affected by the sunspot cycle, which will reach maximum in 1968 and minimum in 1975.

The increase is caused by electrons which are excited by the sun and stream along the earth's magnetic lines of force, arcing high over the equator to winter darkness from the early summer dawn of the opposite polar hemisphere. In the dark ionosphere, they release energy which raises the temperature of particles there and produces chemical changes which result in a barely visible red light. This light will be measured by a photometer for which the National Science Foundation has given $20,000 to the University. At the same time, a radar-like ionosonde at the U of I Aeronomy Station will measure the height and density of overhead electron clouds. Data from these and other instruments will be recorded on tape for analysis by electronic computer.

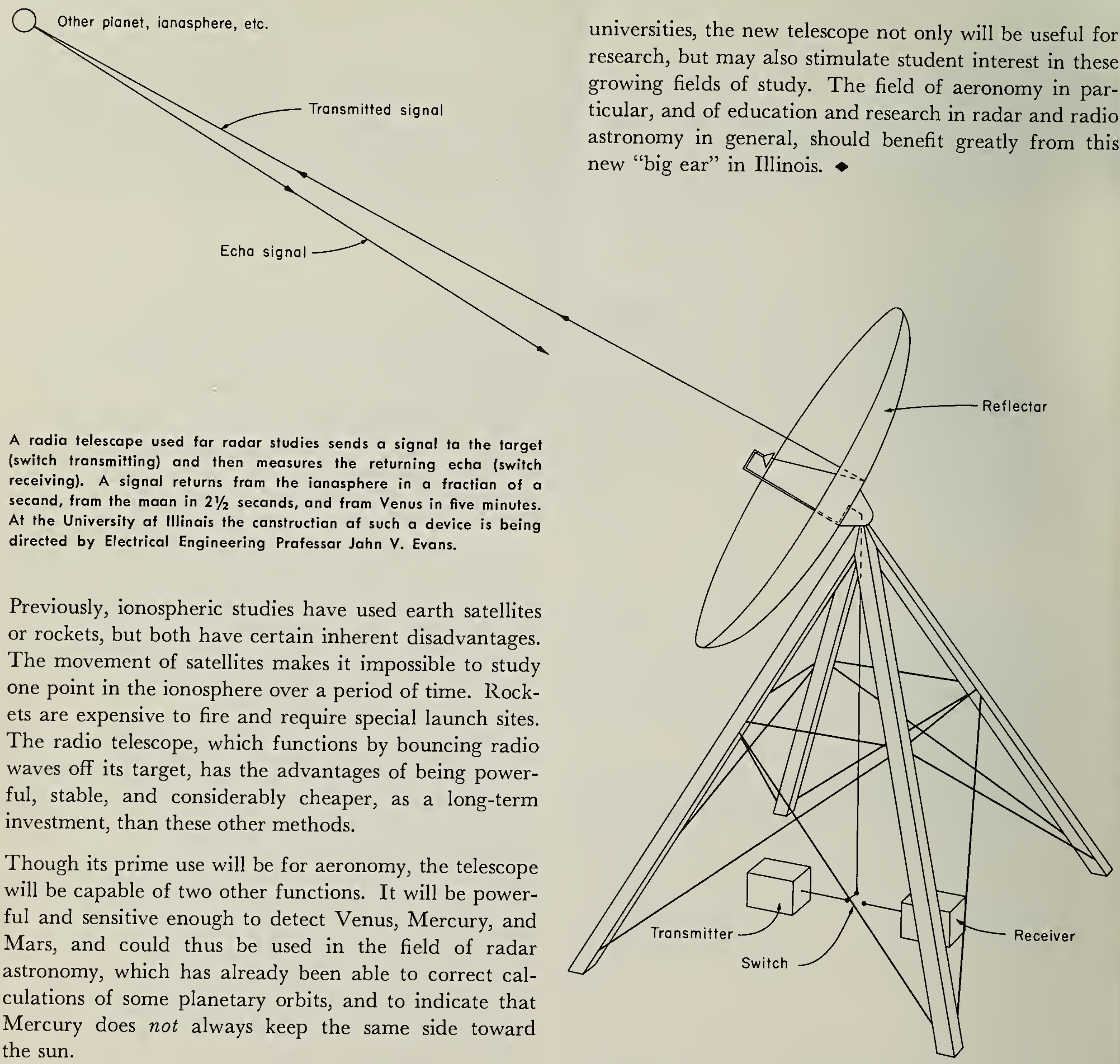
The Illinois equipment will provide one link in a chain of scientific stations set up to observe the winter pre-dawn airglow. The network was suggested recently at the fifteenth general assembly of the International Scientific Radio Union which Bowhill attended in Munich, Germany. ◆

A STRONG NEW EAR

Listening to the sky will be both easier and more fruitful with the completion of a new, ultrahigh-powered radar installation at the University of Illinois. Still in the early planning stage, the device will be used primarily to study the earth's ionosphere. The facility is planned as a large, fully-steerable parabolic antenna with a powerful transmitter. The design is developed from those used in the Ballistic Missile Early Warning System, for which such high-powered radars were first built.

Here to help the Electrical Engineering Department with planning and design for the large radio telescope is Professor John V. Evans. Evans worked at the Jodrell Bank Radio Astronomy Station in England and was one of the first to use the station's 250-foot radio telescope, which is still the world's largest. Since arriving in this country six years ago, he has worked at the Massachusetts Institute of Technology's Lincoln Laboratories, in the field of radar astronomy and aeronomy.

The Illinois telescope will be quite versatile. First, and most important, it will be used for aeronomy, the relatively new field which studies the interaction between the ultraviolet rays of the sun and the molecules of the earth's upper atmosphere. The rays knock electrons off the molecules of the atmospheric gases, producing charged particles which are scattered as trace elements through the ionosphere. Aeronomy studies such things as the kinds and distribution of these charged particles, the chemical reactions that follow the ionization of particles, the balance between the rates of production and loss of such particles, and the character of the neutral atmosphere that surrounds them — all of which appear to change as functions of the sunspot cycle. Other studies in this area yield information about the strange winds that move at high altitudes, the daily expansion and contraction of the atmosphere, and the geomagnetic "tail" that follows the earth on the night side.



A radio telescope used for radar studies sends a signal to the target (switch transmitting) and then measures the returning echo (switch receiving). A signal returns from the ionosphere in a fraction of a second, from the moon in 2½ seconds, and from Venus in five minutes. At the University of Illinois the construction of such a device is being directed by Electrical Engineering Professor John V. Evans.

Previously, ionospheric studies have used earth satellites or rockets, but both have certain inherent disadvantages. The movement of satellites makes it impossible to study one point in the ionosphere over a period of time. Rockets are expensive to fire and require special launch sites. The radio telescope, which functions by bouncing radio waves off its target, has the advantages of being powerful, stable, and considerably cheaper, as a long-term investment, than these other methods.

Though its prime use will be for aeronomy, the telescope will be capable of two other functions. It will be powerful and sensitive enough to detect Venus, Mercury, and Mars, and could thus be used in the field of radar astronomy, which has already been able to correct calculations of some planetary orbits, and to indicate that Mercury does *not* always keep the same side toward the sun.

The third capability of the proposed telescope is for radio astronomy — the study of radio signals originating in space. At present, some of the most exciting sources of cosmic noise are galaxy-like masses that appear to be exploding somewhere beyond the Milky Way. The radio signals they emit are far stronger than any produced on earth.

The multi-purpose features of this installation could benefit the scientific community of the entire Midwest. Departments not primarily concerned with aeronomy will be able to use the facility in its other capacities. Indeed, cooperation in planning the project is being sought from other universities through the Committee on Institutional Cooperation. Located near these large universities, the new telescope not only will be useful for research, but may also stimulate student interest in these growing fields of study. The field of aeronomy in particular, and of education and research in radar and radio astronomy in general, should benefit greatly from this new "big ear" in Illinois. ◆

UNDERGRADUATE RESEARCH GRANT

Under an $11,200 National Science Foundation grant, eight juniors and seniors in the University of Illinois Department of Civil Engineering will be offered special opportunities for independent research in their own fields of interest. The funds will provide financial assistance to students during the winter semesters and full-time support during the summer session. NSF and Department funds also pay for equipment and other costs, according to Professor Richard N. Wright, who is in charge of the program. The grant was introduced in 1959.

The students' research projects cover the entire field of civil engineering. Each student has a faculty supervisor available for guidance when problems arise, but is encouraged to work as independently as possible. The program gives undergraduates the opportunity to become acquainted with research and better decide whether to enter fields of engineering research or of applied engineering when they graduate. Since the program began, 77 students have taken part. Of those who have been graduated, 50 have gone on to advanced study, 33 have received master's degrees, and six, doctor's degrees.

Wright said that similar, though not as intensive, experience is gained by many other students through part-time work on Departmental research which, in the Department of Civil Engineering, involves an annual budget of nearly two million dollars. ◆

JET SET

Fellows leave their trunks at home when they visit the swimming pool in the University of Illinois Hydraulics Engineering Laboratory, but it doesn't mean they're splashing *au naturel*: The pool is used to study a common but seldom-studied flow pattern, and the engineers don't even get wet.

The study, directed by Civil Engineering Professor W. H. C. Maxwell, examines the velocity patterns of a water jet discharging just beneath the surface of a reservoir. Power plants, sewer systems, navigation locks, and siphon spillways frequently use such outlets. From the knowledge gained in the study engineers may be able to calculate distributions of thermal, radioactive, or other kinds of pollutants downstream from their outlets; predict sediment concentrations near the mouths of silt-laden streams; and make more rational decisions about the design of many kinds of hydraulic structures.

Maxwell has found that the influence of the reservoir's air-water "free surface" on the behavior of the flow is considerable. The highest-velocity part of the flow gradually rises to the surface as it travels from its source, quite unlike the pattern of a deeply submerged jet, and the flow spreads further laterally close to the free surface.

While the study has uncovered some intriguing peculiarities of the near-surface flow, it has not fully explained these peculiarities. Maxwell's search for the explanation provides a rare hot-weather opportunity: he can throw himself into his work. ◆

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Comments on editorial policy and format of *Engineering Outlook*:

Centennial Calendar

A centennial lecture, "Political Problems in Implementing Engineering Decisions," will be given on April 6, 1967, by the Hon. Herbert Hollomon, Assistant Secretary of Commerce, U.S.A.

A book, *Men and Ideas in Engineering,* by R. A. Kingery, R. D. Berg, and E. H. Schillinger, will be published by the University Press in May. The book will describe the 100-year course of engineering at Illinois.

May 26, 1967, is the date scheduled for the dedication of the University's Materials Research Laboratory. Dr. Frederick Seitz, physics professor at the University of Illinois now on leave as president of the National Academy of Sciences, will be guest speaker.

PEOPLE AND PLACES

Named as an honorary consultant to the United Nations Educational, Scientific and Cultural Organization (UNESCO) is Civil Engineering Professor **Ven T. Chow.** His appointment concerns the improvement, comparison, and standardization of instruments and techniques to be used in the International Hydrological Decade.

Associate Professor **Thomas K. Liu** of the Department of Civil Engineering has received a Fulbright grant and a postdoctoral fellowship from the Royal Norwegian Council for Scientific and Industrial Research. On a leave of absence from the University, Professor Liu will join the Norwegian Geotechnical Institute in Oslo this summer, and will remain through the summer of 1968. He will perform research on porewater pressures and movements in Norwegian earth dams.

The American Society of Civil Engineers has awarded its Walter L. Huber Civil Engineering Research Prize for 1966 to Professor **L. R. Shaffer.** Cited was his work in developing a computerized system for helping construction contractors make decisions related to business operations.

Professor **Kenneth J. Trigger** of the University of Illinois Department of Mechanical and Industrial Engineering has been named the first U of I Alcoa Professor. Trigger, internationally known for his research on machine tools and metal cutting, will occupy the new post created under a grant from the Alcoa Foundation to link education more closely with industry.

Professor **Charles Taylor,** Department of Theoretical and Applied Mechanics, was elected president of the Society of Experimental Stress Analysis at the organization's annual meeting in Pittsburgh last November. For the last two years Professor Taylor has been vice-president of the Society.

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NOS. 3 AND 4, MARCH–APRIL 1967

In the order listed, this issue contains articles on the following subjects:

FREEZE-THAW TESTING OF BRIDGE PAVEMENTS
A CURE FOR HIGH-VOLTAGE ELECTRICAL BREAKDOWN
CONGRATULATIONS TO THE NAVY CIVIL ENGINEER CORPS
A NEW TRAVEL PLAN FOR INTERVIEWING STUDENTS
ULTRASONIC EXAMINATION OF WELD FLAWS
SALARIES OF FEBRUARY GRADUATES

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QUICK-FROZEN BRIDGES

"Everybody complains about the weather," goes the old saw, "but nobody does anything about it." Well, engineers are doing something about it in the University of Illinois Talbot Laboratory: they're making it worse.

The climatic condition is a local one, however, and ultimately it should be beneficial. Inside a specially designed environmental test unit, researchers under the direction of Theoretical and Applied Mechanics Professor Clyde E. Kesler are freezing and thawing slabs of reinforced concrete like those used in bridge decks. As the slabs are frozen and defrosted they are subjected to either static or cyclic stresses, and washed with a salt solution. Thus the tests simulate closely the winter wear on actual bridges.

The garage-sized test unit is automatically controlled to produce three freeze-thaw cycles per day, using both heating and refrigeration systems. At this rate it can simulate a normal Illinois winter in just ten days.

The project, headed by Joseph P. Callahan with the consulting assistance of Civil Engineering Professor Chester P. Siess, is sponsored by the National Cooperative Highway Research Program of the Highway Research Board. ◆

WHISKER TROUBLE

Somewhere in space an unmanned probe turns on its electric ion engine for a mid-course correction: there is a blinding flash, a jolt shakes the craft, and the engine stops. In California an atom smasher requires a site two miles long because its limited-voltage electrodes need miles to bring subatomic projectiles up to speed.

The trouble in either case might be a whisker, according to University of Illinois researchers under Physics Professors E. M. Lyman, D. Alpert, and research associate D. A. Lee. These Coordinated Science Laboratory collaborators believe that metallic "whiskers" — submicroscopic projections on the surface of electrodes in a high-voltage, high-vacuum environment — are the culprits which initiate electrical breakdown between the electrodes. The whiskers, acting like miniature lightning rods, emit intense beams of electrons which pass through the vacuum from the negative to the positive electrode. As the beam currents pass through the whiskers, they heat them. When one of the whiskers melts, a catastrophic microexplosion occurs, creating a cloud of metallic ions which precipitates the discharge avalanche between the electrodes.

The result can mean failure of the high-voltage end of the space engine or a limitation on the voltage that can be applied to a scientific apparatus such as an atom smasher. The problem of high-voltage breakdown, under study for 50 years, is still not fully understood. Even the new whisker hypothesis has yet to explain why, when, and where the whiskers will appear.

The theory has led to some practical progress, however. The voltage-holding capabilities of the electrodes can be raised by shortening or blunting the whiskers, reducing the heating currents through them. Electrode treatments such as polishing seem to have little effect on the whiskers, since they seem to be created after the high voltage is applied, so the Illinois researchers have developed an improbable-sounding but useful remedy. A small quantity of gas is introduced into the vacuum chamber, and the electrode voltage is raised just high enough that the whiskers begin to release appreciable numbers of electrons. In traversing the chamber, the electrons strike and ionize any gas molecules in their paths. The resulting ions fall back onto the whiskers, blunting them and reducing their electron emission. After this "selective sputtering" treatment is complete the gas is removed, leaving the electrodes — well, not clean-shaven, but at least electronically more tenacious.

The selective sputtering treatment has enabled the CSL researchers to maintain voltages without sparking up to four times as large as with untreated electrodes. To prove further that the electronic five o'clock shadow is not just a figment of the imagination, electron microscope photos have been made which substantiate the presence of the whiskers (see photograph). Theoretical calculations show that really smooth electrodes could support voltages as much as 100 times as high as those currently attainable. Further progress toward this ideal could make many kinds of scientific and space devices more compact and powerful, and might make feasible new methods of high-voltage power generation. ◆

Projections less than a thousandth of an inch high are blamed by University of Illinois Coordinated Science Laboratory investigators under Physics Professor E. M. Lyman for the premature breakdown of high voltages between electrodes in a vacuum. Seeking ways to solve the problem, they have evolved a technique called "selective sputtering" which blunts the whiskers and impairs their effectiveness as miniature "lightning rods."

CIVIL — NOT CIVILIAN — ENGINEERING

The University of Illinois and the Navy Civil Engineer Corps, both celebrating centennials this year and today working closely together, were established in 1867 within three days of each other but hundreds of miles apart. The University was chartered February 28, 1867, by the Illinois State Legislature in Springfield. The Navy Civil Engineer Corps was established March 2, 1867, by the federal Congress in Washington, D. C. The University opened the next year on March 2, which was the Navy engineers' first birthday, but for several decades the two organizations were as far apart as the East Coast and the Midwest.

They first approached each other in 1945, when a Naval Reserve Officer's Training Corps unit was established at the University. Many men commissioned have earned their degrees in civil engineering. In 1955 the Navy Civil Engineer Corps began sending officers to the University to earn advanced degrees in civil engineering. More than 30 have come.

Usually at any one time at least four officers, in grades from ensign to lieutenant commander, are enrolled as advanced students in the U of I. The ensigns are men who are unusually outstanding in college. Two years ago the U. S. Coast Guard followed its fellow seagoing service in sending officers inland to Illinois. Ten Coast Guard officers, lieutenants and lieutenants junior grade, currently are at the U of I earning bachelor's degrees in civil engineering. ◆

UNDERGRADUATE RESEARCH PROGRAM CONTINUES UNDER NSF GRANT

The Department of Civil Engineering will continue an undergraduate research program, started in 1959, under a new $11,200 National Science Foundation grant. The program offers special opportunities for independent research in a field of the student's interest, and gives him the opportunity to become acquainted with research and better decide whether to enter research or applied engineering after graduation. Professor Richard N. Wright is in charge. ◆

FLY NOW, PAY LATER FOR INTERVIEW TRAVEL

The engineering student's last semester can be financially harrowing: just when his college finances are weakest, interview trips to prospective employers may administer the *coup de grace.* The knowledge that his hosts will reimburse him seldom eases the fiscal pinch of paying for air travel tickets.

Now he can soften these shocks to his bank account. At the University of Illinois Urbana campus, a student travel representative, Andy Inn, can arrange credit travel for interviewing students. All the student need do is make his travel reservations through Mr. Inn, and establish that his travel expenses are to be reimbursed. A letter of authorization from the company for the visit is adequate verification. For further information contact Andy Inn at 228 Weston U.R.H., Champaign, Illinois 61820. His telephone number is 332-1932. ◆

PROFESSOR STREHLOW NAMED TO TWO INTERNATIONAL PROGRAMS

Professor Roger A. Strehlow of the Department of Aeronautical and Astronautical Engineering has been named to two posts in connection with international activities of the Combustion Institute. He has been named to the editorial advisory board of *Combustion and Flame*, the Institute's bimonthly journal, published in England, and to the papers subcommittee for the twelfth International Symposium on Combustion to be held July 14-19, 1968, at the University of Poitiers, France.

The Institute, with headquarters in Pittsburgh, deals with all phases of combustion, from explosions to forest fires and from furnaces to jets and rockets. The particular interest of Professor Strehlow, who has been at Illinois since 1960, is in gaseous detonations. ◆

SOUND FOR SOUNDNESS

Listening for flaws has always been the music critics' province. Now engineers are doing something along that line, but they don't need perfect pitch.

Instead of worrying about the tempos and tempers of prima donnas, University of Illinois civil engineers under the direction of Professors W. H. Munse and J. B. Radziminski are concerned with the reliability of skyscraper frames, bridges, ship hulls, and other welded steel structures. They're working to improve this reliability by using sound waves to find the internal weld defects that could develop into full-fledged failures.

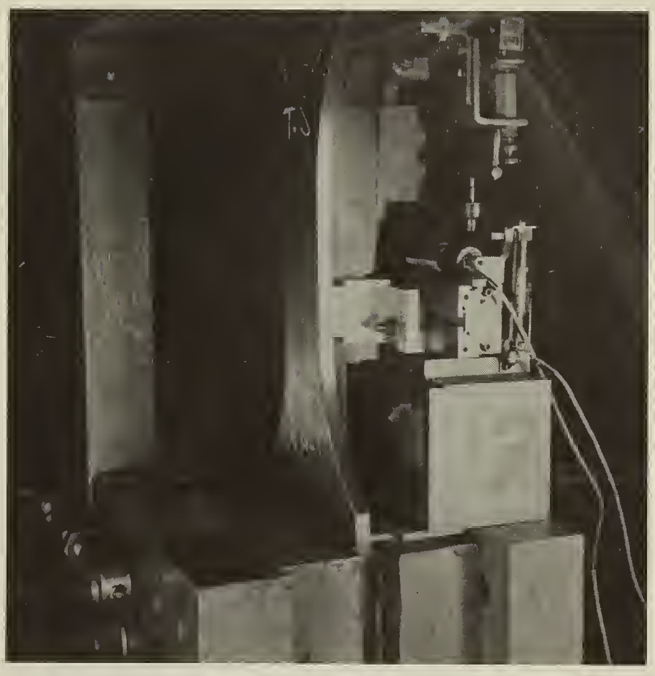
The ultrasonic technique, which is gaining widespread use, sends sound pulses 500 times too high-pitched to be heard by the human ear through the metal under examination. The sound waves are deflected by discontinuities such as slag inclusions and cracks, and are monitored by a receiver. The receiver records the reflected waves as blips on a special screen.

Professor Radziminski is using this sonar-like technique to observe welds in high-strength steel as the welds are subjected to repeated loads. The ultrasonic test equipment not only determines the location of internal weld defects, but also pinpoints the fatigue cracks which originate at these flaws. From the study has come information on the number of load cycles required to initiate such cracks, and the rate of subsequent crack growth leading to eventual failure of the weld. This knowledge will help engineers judge how often welded structures should be inspected to detect fatigue damage, and remedy potential disasters before they happen. ◆

WHERE THEY WENT, AND WHY

The average beginning salary for February graduates in engineering from the University of Illinois is $247 more a month this year than it was ten years ago — and $99 more than the highest paid graduate of 1957. February engineering graduates of 1967 from Illinois are starting at an average of $714 a month, compared to $467 received by February graduates in 1957. This year's top salaries are $800 a month, received by an electrical and a mechanical engineer. Ten years ago the top was $615 to an aeronautical engineer.

The percentage of graduates going on to advanced training has more than tripled in a decade. This year 31 per cent are seeking further education; in 1957 only 9 per cent did. According to Mrs. Pauline V. Chapman, Placement Director for the U of I College of Engineering, 19 per cent of February graduates are going into aerospace and missiles, 17 per cent into electronics, 9 per cent into communications, 8 per cent to state government jobs, and 7 per cent into military service. ◆



A metal specimen, subjected to fatigue conditions of repeated loads, is literally sounded for flaws by the transducer pictured above, in conjunction with the oscilloscope (center, below) and the plotter (right, below). In University of Illinois studies directed by Civil Engineering Professors W. H. Munse and J. B. Radziminski, the equipment is used to locate welding flaws with ultrahigh-frequency sound. The plotter graphs the three-dimensional location of the transducer, and the oscilloscope reveals flaws as sonar-type "blips."

ADDITIONAL $63,000 GRANTED FOR WATERSHED HYDRAULICS

A $63,000 continuation grant from the National Science Foundation has been received for research on watershed hydraulics. The research is being carried on under Professor Ven Te Chow in the Department of Civil Engineering. It brings to $361,650 the total provided by NSF for this work.

The research is the first scientific study to answer the practical engineering question of what factors control the flow of rain down a hill or across a slope. Under Professor Chow's direction, the University has built a unique computer-controlled rainmaking machine in which terrain and rain conditions can be controlled and duplicated at will. The machine has drawn international interest. ◆

Centennial Calendar

A book, *Men and Ideas in Engineering,* by R. A. Kingery, R. D. Berg, and E. H. Schillinger, will be published by the University Press in May. The book will describe the 100-year course of engineering at Illinois.

May 26, 1967, is the date scheduled for the dedication of the University's Materials Research Laboratory. Dr. Frederick Seitz, physics professor at the University of Illinois now on leave as president of the National Academy of Sciences, will be guest speaker.

PEOPLE AND PLACES

Professor **Harry G. Drickamer** of the University of Illinois has been selected by the American Physical Society to be the fifteenth recipient of the Oliver E. Buckley Solid State Physics Prize. The $1,000 prize is endowed by Bell Telephone Laboratories. It will be presented March 29 at the Society's national meeting in Chicago. Drickamer is Professor of Chemical Engineering and Physical Chemistry in the College of Liberal Arts and Sciences and a member of the Materials Research Laboratory and the Center for Advanced Study in the U of I.

He is cited "for experimental skill and inventiveness, combined with originality, imagination, and physical insight to obtain results of fundamental general significance on the effects of very high pressures on solid-state and molecular electronic structure."

Drickamer uses pressures up to nine million pounds per square inch to investigate the chemical, physical, electrical, and optical properties of matter. For this interdisciplinary research he was honored February 21 by the American Institute of Chemical Engineers with the first Alpha Chi Sigma Award.

Among the most recent recipients of the Lincoln Medal, awarded annually by the Lincoln Academy of Illinois for contributions to human progress, was **William C. Ackermann,** Professor of Civil Engineering and Chief of the State Water Survey. His award was for contributions to technology.

Professor **Jerry S. Dobrovolny,** head of the Department of General Engineering, was elected vice-president of the American Technical Education Association at the sixtieth annual convention of the American Vocational Association in Denver. The American Vocational Association is the only national professional group devoted exclusively to vocational and practical arts education.

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

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In the order listed, this issue contains articles on the following subjects:

CONTINUING STUDIES OF THE IONOSPHERE
PHYSICISTS' MEETING FOR THE WESTON ACCELERATOR
RESEARCH FOR MORE DURABLE ASPHALT ROADS
U OF I SUPPORT BY FEDERAL FUNDS
NASA GRANT FOR SPACE COMMUNICATIONS STUDY
ENGINEERING STUDENT AND ALUMNI AWARDS
AUTHORIZATION TO BUILD THE WORLD'S FASTEST COMPUTER

WHAT'S UP

The sky's the limit to researchers in the University of Illinois Department of Electrical Engineering, especially those working with Professor Sidney A. Bowhill to understand the upper limits of the sky — the ionosphere and protonosphere. Using satellites, rockets, and ground-based instruments, they are studying these regions, more than 40 miles above the earth, for knowledge of wide-ranging importance.

Currently sought are theories which will coordinate previous data and explain their variations. The work is supported by a $92,900 grant to the University of Illinois from the National Science Foundation. The new award will continue upper-atmosphere studies which began under an earlier $87,000 NSF grant.

Understanding the ionosphere, of practical importance to long-distance radio communications, involves fundamental facts in the rapidly expanding area of space science. The ionosphere is composed of changing layers of clouds of electrically charged particles at heights of 40 to 500 miles above the earth.

The Electrical Engineering Department, a center for ionosphere research, is interested in the effect of major weather changes in the lower atmosphere and stratosphere upon the ionospheric layers. High and low pressure centers sweeping across the earth and jet streams overhead create great pressure waves at still higher levels. Behaving like swells of the ocean, these move the thin, high-level gases at velocities approaching the speed of sound.

The movement of ion clouds carried along by these waves is being measured by the University of Illinois from a new Aeronomy Field Station northeast of the campus at Urbana. The waves will be discussed next summer in a two-day symposium to be held in Geneva, Switzerland, under sponsorship of the International Association of Geomagnetism and Aeronomy and the International Scientific Radio Union.

Another area to be explored under the grant is the protonosphere. Into this area, thousands of miles above the earth, ions created by the sun's rays in gases of lower levels drift during the day. At night they drift down again, keeping the highest ionosphere layer, 150-500 miles above the earth, from disappearing. ◆

U OF I PHYSICISTS ATTEND WESTON ACCELERATOR MEETING

Twenty members of the University of Illinois faculty attended a meeting April 7 and 8 of 325 physicists interested in the 200 billion electron volt atom smasher to be built at Weston, Illinois. The two-day technical meeting at Argonne National Laboratory was sponsored by Universities Research Association, Inc., an organization of 46 universities which has offered its services to the Atomic Energy Commission to design, construct, and operate the new accelerator.

The University of Illinois is a member of URA, and Professor Edwin L. Goldwasser of the physics faculty is chairman of the URA Scientific Committee, which made arrangements for the meeting. Those attending from the U of I included 16 from Urbana and four from Chicago Circle.

Governor Otto Kerner opened the sessions, which included a trip to the Weston site of the new machine, the world's largest proton accelerator. The meeting included discussions of theoretical and experimental problems associated with high energies; plans for developing the accelerator, laboratory, and site at Weston; and plans for interaction between the laboratory and physicists. ◆

As part of a University of Illinois project aimed at improving blacktop roads, students are evaluating the viscosity characteristics of asphalt. In the test, thin films of asphalt are sheared between parallel plates at a constant temperature and load. Continuous recordings are made of the deformations as they occur. The study is directed by Civil Engineering Professor Moreland Herrin and instructor Charles Marek.

STICKY SUBJECT

The case for blacktop roads is not black-and-white: asphalt pavements are inexpensive, resilient, and free from the thump of expansion joints, but they soften in hot weather. Two University of Illinois engineers are taking a really close look at the sticky problem of building durable asphalt roads, in the hope that such highways can be designed more precisely. Civil Engineering Professor Moreland Herrin and instructor Charles Marek know that thinner layers of asphalt between the stones of the aggregate in the paving mixture create a stronger roadway, and that the bituminous material itself seems to be composed of chain-like molecules. Apparently the tangling of these "chains" lends strength to the binder and the pavement. Excessive loads snap these chains and cause the pavement to fail.

Most of these characteristics of asphalt roads are well known, but the reasons behind this behavior are not. Herrin and Marek are seeking answers to why bituminous pavement behaves the way it does. Besides their interest in the influence of molecular composition on the behavior of asphalt, they are trying to explain how and why the material deforms and fails. The starting point of their study is an investigation of the tensile strength of bituminous films — a characteristic closely related to the strength of the pavement itself. The knowledge they acquire should help engineers design more durable, trouble-free highways. ◆

ENGINEERING "CLINICAL PRACTICE" SUGGESTED

The engineer of tomorrow may work as closely with "the patient" as does the medical doctor today, J. Herbert Hollomon, Acting Undersecretary of Commerce, declared April 6 in a centennial address at the University of Illinois. He defined society as "the patient" and asserted that the engineer needs "clinical practice."

Lacking a relationship to the layman equivalent to the doctor-patient relationship, the engineer traditionally has had greater acceptance problems than the medical doctor, Hollomon said. As he aspires to professionalism, the engineer must seek new ways to serve society.

"By the nature of his training, the engineer instinctively rests his case on his product, expecting it to speak for him," said Hollomon, an engineering executive with long experience in industry and government. "That may have been possible when the engineer's output was bridges, battles, and buildings. But today the engineer, as often as the scientist, works with science, symbols, and society." ◆

UNIVERSITY OF ILLINOIS SIXTH IN TOTAL SUPPORT BY FEDERAL FUNDS

The University of Illinois ranks sixth in the nation in federal support for academic science and other educational activities during 1965, according to the National Science Foundation. A report prepared for the Office of Science and Technology lists the University as having received $44,892,000 during the period.

The report indicates that the top 100 institutions in totals received 77 per cent of the funds and graduated nine-tenths of the nation's doctors of philosophy in engineering and science. The top ten institutions, among them Illinois, received 25 per cent of the funds and graduated 29 per cent of the Ph.D.'s.

Massachusetts Institute of Technology, which received $59,601,000, was ranked first. After M.I.T. and Michigan were the following: University of California at Los Angeles, Columbia, Cornell, Illinois, the University of California (Berkeley), Stanford, Minnesota, and Harvard. ◆

KEEPING 'EM TALKING WHILE THEY'RE FLYING

The University has received a $45,586 grant from the National Aeronautics and Space Administration for research into the communications blackout met by astronauts during reentry into the atmosphere. The grant brings to $129,052 the total received since 1964 for study into problems related to antennas and probes in gaseous plasmas. The project is being conducted under professors Georges A. Deschamps, Yuen T. Lo, and Raj Mittra of the Department of Electrical Engineering. ◆

ENGINEERS HONOR FOUR STUDENTS, FIVE ALUMNI

Four engineering students and five nationally known alumni were honored May 4 in the College of Engineering third annual Awards Convocation.

The students were Stuart E. Simon of Chicago, who received the Hamilton Watch Award; William R. Veatch of Thawville, the Honeywell Award; William M. Warnock of Alexis, the Harvey H. Jordan Award; and Richard G. Anderson of Tacoma, Washington, the Lisle Abbott Rose Memorial Award.

Alumni Award Medals went to Thomas Baron of Houston, Texas; Henry T. Heald of New York; Herman C. Krannert of Indianapolis; Frederick C. Lindvall of Pasadena, California; and William E. Shoupp of Pittsburgh, Pennsylvania.

Simon, a senior in mechanical engineering, is being recognized for combining proficiency in his field with achievements in the social sciences and humanities; Veatch, junior in physics, for distinguished performance and leadership; Warnock, electrical engineer, valedictorian of midyear graduates, for scholastic standing and character; Anderson, senior in civil engineering, for "technical experience combined with cultural breadth, depth, and sensitivity." ◆

ARPA AUTHORIZES DEVELOPMENT OF ADVANCED UNIVERSITY COMPUTER

The Advanced Research Projects Agency (ARPA) of the Department of Defense has approved selection of the Burroughs Corporation, Paoli, Pennsylvania, for the engineering development of ILLIAC IV, an experimental parallel processing computer being designed at the University of Illinois. The U of I, ARPA's prime contractor for parallel processing computer research, will negotiate the contract with the Burroughs Corporation. The contract is expected to amount to several million dollars.

The ILLIAC IV project will be directed by Computer Science Professor Daniel Slotnick. Present computers involve the use of one control unit interacting with one arithmetic unit. The ILLIAC IV will have four control units interacting with more than 250 arithmetic units, which will increase the speed of data processing from 500 to 700 times over present computers and 100 times over any computer known to be in development. ◆

ORDER FORM FOR NEW PUBLICATIONS

☐ Bulletin 488, *Traffic Linkage Patterns Between a Metropolitan Area and the Communities Within Its Region of Influence*, by G. W. Greenwood. *$4.00.*

☐ Bulletin 490, *Social Factors Associated with Traffic Generation in a Metropolitan Area of 75,000 Population*, by R. W. Janes. *$3.00.*

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☐ *Catalog of Technical Publications of the University of Illinois College of Engineering, 1904–1967. No charge.*

☐ *A Summary of Engineering Research, 1966. $5.00.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

Send with remittance to Engineering Publications, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801.

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Centennial Calendar

May 26, 1967, is the date scheduled for the dedication of the University's Materials Research Laboratory. Dr. Frederick Seitz, physics professor at the University of Illinois now on leave as president of the National Academy of Sciences, will be guest speaker.

A book, *Men and Ideas in Engineering*, by R. A. Kingery, R. D. Berg, and E. H. Schillinger, will be published by the University Press in June. The book will describe the 100-year course of engineering at Illinois.

PEOPLE AND PLACES

Nathan M. Newmark, Head of the Department of Civil Engineering in the University of Illinois, has received an honorary membership in the American Concrete Institute. It was presented by Arthur R. Anderson, Institute president, at the awards luncheon of the 63rd annual ACI convention in Toronto, Canada.

Newmark was honored for his numerous contributions to progress in the fields of structural analysis and design and of reinforced concrete research.

Professor **William C. Rose**, emeritus member of the chemistry and chemical engineering faculty, has been named by President Johnson as one of eleven recipients of the National Medal of Science for 1966. Rose was cited for "the discovery of the essential amino acid threonine and for the subsequent brilliant studies elucidating the qualitative and quantitative amino acid requirements of man and of animals." He is the third University of Illinois faculty member to receive this award, which was presented in 1964 to Professor **Roger Adams**, also an emeritus member of the chemistry and chemical engineering faculty at Urbana, and in 1965 to **John Bardeen**, Professor of Electrical Engineering and of Physics.

The National Academy of Engineering has announced the election of four University of Illinois engineers to its membership. The new members, elected on the basis of outstanding contributions to engineering theory and practice or to the pioneering of new and developing fields of technology, included Civil Engineering Professor **William C. Ackerman**, for research on water resources; Civil Engineering Professor **Don U. Deere**, rock mechanics; Electrical Engineering Department head **Edward C. Jordan**, direction finding and antenna research; and Civil Engineering Professor **Chester P. Siess**, reinforced concrete construction. The National Academy of Engineering, with the National Academy of Science, advises the federal government on matters of science and technology.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NO. 6, JUNE 1967

In the order listed, this issue contains articles on the following subjects:

- STUDY OF UNDERWATER FLOW PATTERNS
- ENGINEERING CENTENNIAL BOOK
- UNDERGRADUATE SOLID STATE LABORATORY
- SOIL STABILIZATION BULLETIN
- A NEW IONOSPHERE STUDY
- SPACE VEHICLE DESIGN COURSE

JET SET

Fellows leave their trunks at home when they visit the swimming pool in the University of Illinois Hydraulics Engineering Laboratory, but it doesn't mean they're splashing *au naturel*: The pool is used to study a common but seldom-studied flow pattern, and the engineers don't even get wet.

The study, directed by Civil Engineering Professor W. H. C. Maxwell, examines the velocity patterns of a water jet discharging just beneath the surface of a reservoir. Power plants, sewer systems, navigation locks, and siphon spillways frequently use such outlets. From the knowledge gained in the study engineers may be able to calculate distributions of thermal, radioactive, or other kinds of pollutants downstream from their outlets; predict sediment concentrations near the mouths of silt-laden streams; and make more rational decisions about the design of many kinds of hydraulic structures.

Maxwell has found that the influence of the reservoir's air-water "free surface" on the behavior of the flow is considerable. The highest-velocity part of the flow gradually rises to the surface as it travels from its source, quite unlike the pattern of a deeply submerged jet, and the flow spreads further laterally close to the free surface.

While the study has uncovered some intriguing peculiarities of the near-surface flow, it has not fully explained these peculiarities. Maxwell's search for the explanation provides a rare hot-weather opportunity: he can throw himself into his work. ◆

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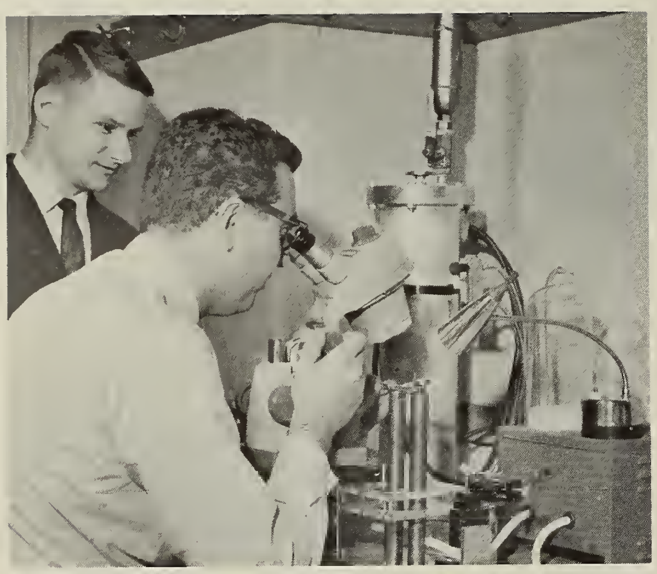
ENGINEERING: HOW IT WAS, HOW IT IS

Some of the best-known engineers and engineering projects of the University's first century are the subjects of a new book, *Men and Ideas in Engineering,* published by the University of Illinois Press for the College of Engineering. A well-illustrated, readable book that focuses as sharply on ideas and people as on the technical aspects of machines, *Men and Ideas* relates a dozen stories that range from finding a cure for railway "rail cancer" to the invention of the betatron, from pioneering the use of ultrahigh-frequency sound for mapping the brain to the creation of the ILLIAC series of computers.

The change shown in engineering research and education over Illinois' first century reflects many of the changes in engineering generally: an increasing emphasis on a scientific approach, rather than "cut and try," and an increasing influence and interaction with the values and economy of the rest of society. In the book's pages the dual pictures of an engineering professor as an ivory-tower hermit or "grease monkey" merge with time into a figure called upon to emphasize basic scientific principles in his teaching, engage in more and more esoteric research, and at the same time play the sometimes earthy games called "Publish or Perish," and "While You're Up, Get Me a Grant."

More than the story of one school's accomplishments, the book uses its "men behind the machines" point of view to convey the excitement and the misfortune, ignorance, and bureaucratic indifference which affect the engineer as much as they do anyone else. *Men and Ideas,* by showing both the genius and the fallibility of the engineer, refutes the misconceptions which surround him, suggesting instead respect and caution for him as an ordinary fellow in an extraordinarily influential line of work.

The book, written by Elisabeth Schillinger, Rudy Berg, and Alan Kingery, is available at $5.00 (plus 4 percent state tax) from the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. ◆



In the solid state electronics laboratory of the University of Illinois, student Albert B. Rigoni uses an alloying process to make a semiconductor diode. Supervising is Professor Ben G. Streetman. In this laboratory electrical engineering undergraduates learn processes and try techniques in solid state electronics, exploring exciting new developments of their field.

SOLID EDUCATION

At Illinois, as in engineering colleges elsewhere, an idea born in the research laboratory today may be found in the graduate seminar tomorrow and the undergraduate class the next morning. Professor Edward C. Jordan, Electrical Engineering Department head, says, "In electrical engineering the time from conception of new ideas to their application is short. Our job is to train students to know new technologies and to be able to keep abreast of changes. The transistor was invented in 1948 and in less than ten years was a part of our technology. Integrated circuits came into general use in five years. The speed of change is continually faster." No course in the Department of Electrical Engineering at Illinois is the same as it was five years ago. Many are completely new.

Jordan explains that something new — an idea like cryogenics, a device like the transistor, or an application — appears first in the research laboratory. Research involving it becomes a part of training for graduate students. What was a graduate level subject quickly becomes a part of undergraduate optional work, and may soon become a part of required training for all students.

A prime example is in the field of solid state electronics. *Solid state* is today's magic term in the field — as *transistor* was a few years ago, or *vacuum tube* a generation back. Solid state involves transistors, diodes, microelectronics, and other devices.

At Illinois, research is probing for a better understanding of solid state devices, new ideas, and new applications. Internationally known professors are working in this area in the Departments of Electrical Engineering and Physics, and the Materials Research Laboratory. Among them is Electrical Engineering Professor Chih-Tang Sah, who is developing an idea which promises to shorten the research-instruction circuit: a solid state laboratory for undergraduates. To finance it, an $18,000 National Science Foundation grant was obtained, and the University provided $35,000.

Two staff members — professors George E. Anner and Robert F. Pierret — have worked on the side for a year building special equipment and working with Sah in planning the course. Anner even took a semester off from teaching to put in full time on advanced solid state research.

The laboratory opened last fall with these men in charge. In it, undergraduate students find the finest, most modern equipment to help them understand the basic principles of solid state devices and try the latest techniques in solid state electronics. Here the student can focus his earlier basic courses in chemistry, mechanics, physics, metallurgy, mathematics, and electronics on some of the most exciting new developments of his profession.

Teachers in this course are as excited as the students, and now are working on a similar course concerning integrated circuits, a solid state application for fields from rockets and computers to television and pocket radios. ◆

SOIL STABILIZATION BULLETIN PUBLISHED

"Factors Influencing the Plasticity and Strength of Lime-Soil Mixtures," by Marshall R. Thompson, has been published by the University of Illinois Engineering Experiment Station as Bulletin No. 492. For the study, 39 Illinois soils were researched to determine the influence of lime type, lime percentage, and curing period on the properties of lime-soil mixtures.

Bulletin 492 is available for $3.00 from the Engineering Publications Office, 112 Engineering Hall, Urbana, Illinois 61801. ◆

SKYLIGHT

A red, pre-dawn glow in the winter sky is under study by University of Illinois aeronomy researchers under Electrical Engineering Professor Sidney A Bowhill. The phenomenon, called "airglow," takes place in the rarefied atmosphere 200 miles above the earth.

While some degree of airglow exists all night, a sudden increase occurs before dawn in the winter. This increase occurs simultaneously with sunrise in the corresponding latitude of the opposite hemisphere — north or south — which is enjoying its summer season. The precise time at which the airglow increase occurs is related to distance from the equator. The phenomenon is also affected by the sunspot cycle, which will reach maximum in 1968 and minimum in 1975.

The increase is caused by electrons which are excited by the sun and stream along the earth's magnetic lines of force, arcing high over the equator to winter darkness from the early summer dawn of the opposite polar hemisphere. In the dark ionosphere, they release energy which raises the temperature of particles there and produces chemical changes which result in a barely visible red light. This light will be measured by a photometer for which the National Science Foundation has given $20,000 to the University. At the same time, a radar-like ionosonde at the U of I Aeronomy Station will measure the height and density of overhead electron clouds. Data from these and other instruments will be recorded on tape for analysis by electronic computer.

The Illinois equipment will provide one link in a chain of scientific stations set up to observe the winter predawn airglow. The network was suggested recently at the fifteenth general assembly of the International Scientific Radio Union which Bowhill attended in Munich, Germany. ◆

HELP FROM WITHOUT WE COULDN'T DO WITHOUT

University of Illinois engineering students studying the problems of spacecraft design last semester had some of the best advice in the world. A novel space vehicle design course, offered under the auspices of the James Scholars Program in Engineering, featured speakers from among the country's top experts in aerospace industries and the National Aeronautics and Space Administration. This generous support enabled the course's students to consider specific, realistic, current problems involved in spacecraft design. The guest speakers not only provided up-to-date information concerning the requirements and responses of various space systems, but also described how and why actual design decisions had been made for the vehicles of the United States' space program. Their knowledge and experience provided the course with a practical "real life" approach which would have been impossible without their support.

Dr. Erwin Schmerling, Director of NASA's Space Science Programs, and Dr. Maxime Faget, Director of Engineering and Development of the Manned Spacecraft Center in Houston, Texas, spoke to the class. Dr. Faget originally conceived and proposed the development of a one-man spacecraft which later was used in Project Mercury.

McDonnell Aircraft Co. sent ten experts to speak to the class: Dr. E. R. Jones, Manager, Engineering Psychology Department; Mr. A. Browde, Manager, Space and Missile Electronics; Mr. Robert Sharp, McDonnell's "company astronaut"; and Design Engineers R. W. Stengel, S. C. Boyle, D. E. DeFrees, C. Hinrichs, E. Patton, R. H. Hepper, and R. Schwarz.

Dr. James Gaume, Chief, Aerospace Medicine, Douglas Aircraft Company, spent a week on the campus giving two lectures to the class and consulting with undergraduates, graduate students, and faculty concerning aerospace medicine and physiological problems of space flight. Mr. Serge Golian from the Aeronutronic Division of the Philco Corporation spoke on the topic of instruments for space vehicles and for the investigation of space, and Mr. J. A. MacDonald, Technical Director for Propulsion for the Martin Company, spoke to the class on the subject of propulsion and rocket engines. ◆

POPULAR TECHNICAL REPORT SERIES AVAILABLE

The following series of technical reports, published by the University of Illinois Department of Civil Engineering, has been made available through the Engineering Documents Office:

Report #2. "Extensions of the Critical Path Method Through the Application of Integer Programming," by W. L. Meyer and L. R. Shaffer. $2.00.

Report #3. "An Application of the Theory of Queues to the Forecasting of Shovel Truck Fleet Productions," by J. B. O'Shea, G. N. Slutkin, and L. R. Shaffer. $2.50.

Report #4. "An Evaluation of Some Competitive Bid Strategy Models for Contractors," by B. J. Casey and L. R. Shaffer. $2.00.

Report #5. "The Resource Scheduling Problem in Construction," by J. D. Brand, W. L. Meyer, and L. R. Shaffer. $2.00.

Report #6. "Construction Costs CPM and the Digital Computer," by A. C. Alberga and L. R. Shaffer. $2.50.

Report #7. "COBESTCO Computer Based Estimating Technique for Contractors," by Peter Kramer and L. R. Shaffer. $2.00.

Report #8. "Staged Decision Theory Applied to the Limited Resource Problem," by J. J. Baker and L. R. Shaffer. $2.00.

The reports, widely used by construction companies and other contractors, are also available as a complete set for $12.00. Orders should be sent to the Engineering Documents Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. ◆

PEOPLE AND PLACES

Professor **Seichi Konzo,** associate head of the Department of Mechanical and Industrial Engineering, has received the E. K. Campbell Award of Merit from the American Society of Heating, Refrigerating, and Air Conditioning Engineers. The award, presented by the Life Members Club of the Society, recognizes Konzo's outstanding service and achievement in teaching.

The American Society of Photogrammetry has awarded its $1,500 Wild-Heerbrugg Photogrammetric Fellowship to **T. V. George,** graduate student in civil engineering and research assistant in photogrammetric engineering. George came to the University last fall from India, where he had been on the faculties of the Government Polytechnic Institute at Calicut and Engineering College at Trichur.

Electrical Engineering Professor **Nick Holonyak, Jr.,** has been named a fellow of the Institute of Electrical and Electronics Engineering. The citation is the highest honor the Institute confers upon a member. Holonyak was named for his contributions to the application of solid-state devices in electronics.

James O. Smith, Professor of Theoretical and Applied Mechanics, has been presented with the Western Electric Award of the Illinois-Indiana section of the American Society for Engineering. Smith is recognized "for his outstanding service to students by instilling in them enthusiasm and inspiration for creative endeavor and intellectual development not only while in college but also throughout their careers, for his ability to create harmonious relations by exhibiting a warm and friendly attitude toward the student as an individual, for his active participation and leadership in the activities of professional societies, for his scholarly contributions to the permanent engineering literature, and for the profound influence his textbooks have had in the teaching of undergraduate and graduate students."

Professor **John Bardeen,** of the Departments of Electrical Engineering and Physics and the Center for Advanced Study, is a member of President Johnson's Commission on the Patent System, which recently filed a 35-item report containing recommendations for revisions of the patent system.

Dr. Frederick Seitz, President of the National Academy of Sciences, has appointed Professor **Ven Te Chow,** University of Illinois Department of Civil Engineering, to the Hydrology Subcommittee of the NAS Advisory Committee on Space Programs for Earth Observations. Chow will advise the U. S. Geological Survey on hydrological (water resources) investigations of the earth using spacecraft equipped with remote sensors and radio communication systems, and will provide guidance in the rapid acquisition and transmission of hydrological data.

Chow has also been invited to serve on another NAS advisory group which will conduct a critical study of the U. S. program on the peaceful use of space and advise the National Aeronautics and Space Administration on its future space application development.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NO. 7, SEPTEMBER 1967

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In the order listed, this issue contains articles on the following subjects:

MARINE STRUCTURE RESEARCH
THE ILLINOIS TRIGA REACTOR
CIVIL ENGINEERING BUILDING DEDICATION
AMERICAN CERAMIC SOCIETY MEETING AT THE U OF I
WATER UTILITY MANAGEMENT SHORT COURSE
A SCIENTIFIC STUDY OF MUSIC

MARINE STRUCTURES: THE PERMANENT VERSUS THE WAVE

The power of the sea is seldom clearer than when it meets the man-made. Many a breakwater has crumbled under the surf, and many a sea wall has fallen. There is another kind of failure: The wall may survive undamaged . . . and be more expensive than it needs to be.

A new study in the University of Illinois Civil Engineering Department aims at understanding just what happens when wave meets wall. The result may be fewer failures of either kind.

A project recently initiated in the Department's Hydraulic Engineering Laboratory will study the shock pressures which occur when waves break against a structure. The research is being done by research assistant J. R. Weggel under the guidance of N. M. Newmark, Department head, and Professor W. H. C. Maxwell.

To determine the maximum shock pressure possible, the distribution of the pressure over the structure, and the mechanism which causes the shock pressure to occur, experiments will be performed on test structures in a 100-foot-long wave tank. A wave generator in one end of the tank creates custom-built waves of variable height, length, and frequency. At the other end of the tank is a sloping beach, 40 feet long, where the waves "pile up" and eventually break. It is in this region that the test structures are to be built.

The test structures, vertical walls of various widths, will contain as many as eight miniature pressure gauges mounted at various points. Tape recordings of the signals from these gauges will provide researchers with a permanent record for later detailed analysis. In order to correlate the pressure recordings with the events which occur at the test wall when shock pressures occur, high-speed motion pictures will be taken through a window in the side of the wave tank. Hopefully, analysis of both the pressure records and the films will provide clues to the cause of the shock pressures and help engineers to design stronger and more economical marine structures. ◆

TRIGA GETS BIGGA

The spirit of cooperation between Midwestern universities was never clearer than recently, when the University of Illinois transferred a number of major nuclear reactor components to Michigan State University. The reason: The Illinois reactor is being upgraded to operate at the highest power levels of any TRIGA reactor in the world.

The Illinois TRIGA (Training Research Isotope-production General Atomic) reactor, originally conceived for 10,000-watt output, was modified during construction to produce a steady 100,000 watts. One year after it was built, the reactor was licensed by the Atomic Energy Commission to produce pulses of power up to 250 million watts, one hundredth of a second in duration.

By 1963 it was the only university reactor to be licensed to operate steadily at 250 million watts and to make power excursions to one billion watts. During 1966 the AEC and the NSF contributed funds with the University to upgrade the reactor once again, raising its operating level to a steady three million watts and giving it pulsing capabilities of five billion watts. This level of pulsing power, although short-lived, is comparable to the power requirements of a city the size of Chicago.

To make these extremely high power levels possible, it was necessary to upgrade the reactor to Mark III capabilities — which will be done primarily by installing forced-flow cooling and using stainless steel-clad fuel elements. The reactor's fuel elements are designed to automatically prevent accidental power excursions: whenever the elements' temperature rises, the character of their ingredients lowers the reactor's power output. The present cooling system runs 60 gallons of water per minute through the core of the reactor; the new system will need to pump 3,000 gallons per minute through the core.

The old cooling system, operating console, core, reflector structure, and other components were scheduled for replacement, so the University, with the encouragement of the AEC and the NSF, began to look for another Midwestern university in the market for the skeleton of an excellent — if "used" — reactor.

The search was for an accredited engineering school without a reactor which could make good use of such a machine in graduate engineering education. Michigan State University met these requirements. The arrangements were made with MSU early this year. The Atomic Energy Commission, which owned the fuel for the Illinois TRIGA, agreed to transfer it to Michigan State, where plans are now being laid for the construction of the largest component not included in the transfer — the underground tank to house the reactor core.

Thanks to the help of the Atomic Energy Commission and the National Science Foundation, as well as to the cooperative spirit between the two universities, both Michigan State University and the University of Illinois will soon enjoy greatly improved capabilities for advanced research in nuclear engineering. ◆

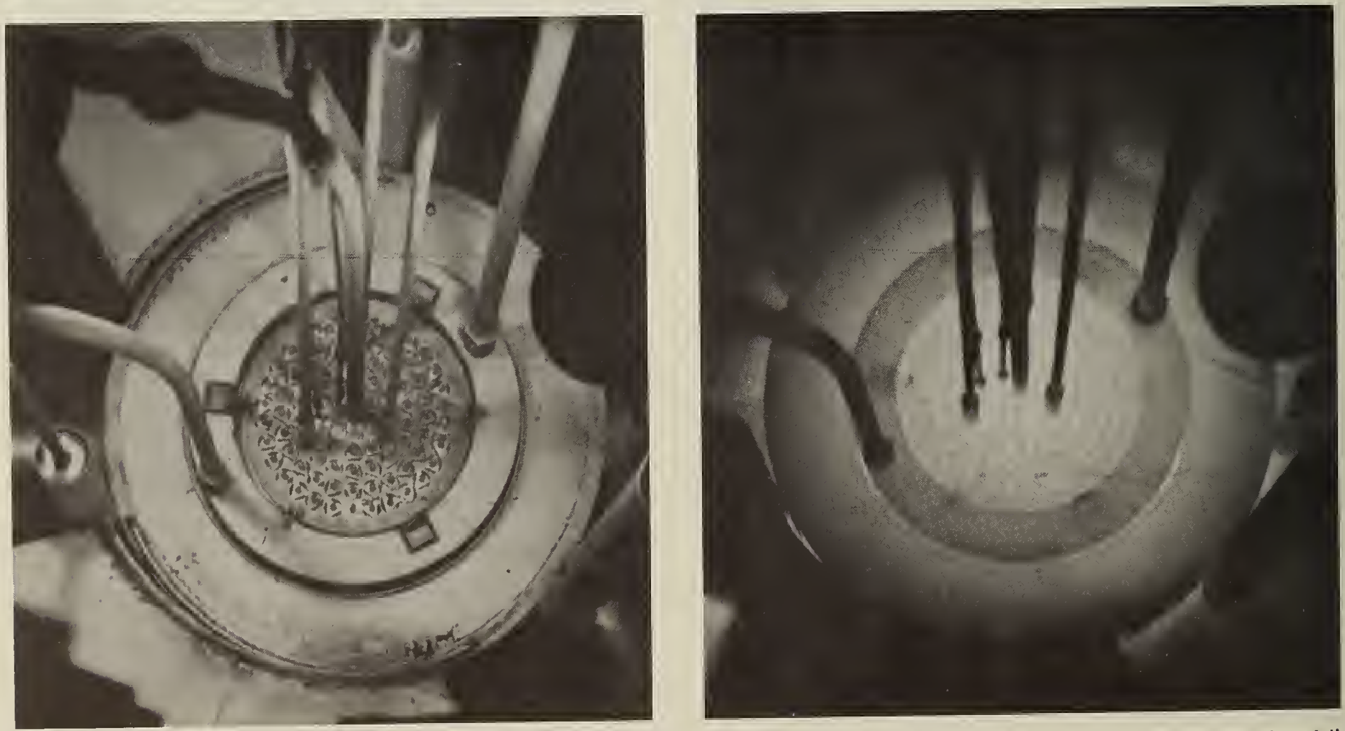
ANNO DOMINI MM

The date 2000 A.D. may have a distant sound, but it is a matter of current concern to educators: They know that today's students will be at the peaks of their careers when the century — and the millennium — ends.

University of Illinois civil engineers are showing their awareness of the future on November 9 and 10, when "A Look Ahead into the Next Century of Civil Engineering Education and Practice" will be the theme of a special conference held as part of the new Civil Engineering Building dedication ceremonies.

To the Civil Engineering Department, the conference marks a special pause for reflection and planning. Lauritus Bjerrum, Director of the Norwegian Geotechnical Institute in Oslo, Norway, has accepted an invitation to be guest speaker at the dedication dinner. Governor Otto Kerner, the University Board of Trustees, University President David D. Henry, J. W. Peltason, Chancellor of the Urbana Campus, William L. Everitt, Dean of the College of Engineering, and Nathan M. Newmark, head of the Department of Civil Engineering, will participate in dedication ceremonies.

Panels of prominent civil engineers and faculty members will discuss civil engineering in the twenty-first century. In the area of rock mechanics, Professors Don U. Deere and A. J. Hendron will co-chair the session. Professors Ven Te Chow and Benjamin B. Ewing will conduct the



The core of the University of Illinois TRIGA reactor houses the circular array of fuel elements shown in the "cold" condition (left) and at full power, self-illuminated by the blue-green glow of Cerenkov electron radiation. The U of I TRIGA is being upgraded to produce a steady three million watts of power, with pulses up to five billion watts, making it the most powerful reactor of its kind in the world.

water resources conference, and Professors Louis R. Shaffer and Steven J. Fenves will head discussions of systems engineering.

The systems approach, the computer, and the replacements for these new tools, as well as the problems the new tools and techniques will meet — these and other equally long-range questions will be the concerns of the conference and the Department, as they must be for an organization dedicated to staying ahead of the times.

Further information on the conference can be obtained from N. M. Newmark, head of the Department of Civil Engineering, University of Illinois, Urbana, Illinois 61801. ◆

U OF I HOSTS CERAMIC SOCIETY MEETING

Twenty-two papers concerning nuclear reactor fuels and materials are being presented September 19–22 at the University of Illinois, at the second meeting of the American Ceramic Society's Nuclear Ceramics Division. Nearly 100 engineers engaged in this new field are attending from industry, research institutes, national laboratories, and universities.

Professor Alfred W. Allen of the Department of Ceramic Engineering, vice-president and member of the ACS executive committee, represents the nuclear ceramics division. Professor Richard M. Fulrath, a U of I alumnus at the University of California at Berkeley, is division chairman. Steven B. Stoddard of Los Alamos Scientific Laboratory, another Illinois alumnus, is a trustee. Joseph Handwerk of Argonne National Laboratory is vice-chairman; Steven C. Carniglia of Atomics International Division of North American Aviation is secretary; and J. Lambert Bates of Battelle Memorial Institute, Pacific Northwest Laboratories, is program chairman.

Professor Marvin Wyman, who heads the U of I nuclear engineering program, will speak at the division meeting banquet, and Professor Arthur L. Friedberg, head of the Department of Ceramic Engineering, will speak at the luncheon. ◆

WATER UTILITY MANAGEMENT SHORT COURSE

The University of Illinois Allerton House conference center will be the site of the Sixteenth Annual Water Utility Management Short Course, to be held October 29–November 2. Designed to aid the water commissioner, manager, and supervisor in improving their management skills, the course is conducted by the U of I through the Bureau of Business Management, the College of Commerce and Business Administration, and the Division of University Extension in cooperation with the Illinois, Indiana, and Wisconsin sections of the American Water Works Association.

Further information can be obtained from Mr. Richard Ulrich, Short Course Supervisor, 116e Illini Hall, Champaign, Illinois 61820. ◆

U OF I SECOND IN BACHELOR'S AND DOCTOR'S, NINTH IN MASTER'S ENGINEERING DEGREES CONFERRED

The University of Illinois is second in the nation in the number of bachelor's degrees and doctor's degrees conferred in engineering; third in all engineering degrees; and ninth in master's degrees; according to a report just issued by the U. S. Office of Education.

The report covers 160 schools for the 1965–66 academic year. They conferred a total of 51,795 engineering degrees. The top five schools were Purdue, with 1,477; Massachusetts Institute of Technology, with 1,283; Illinois, with 1,177; California at Berkeley, with 1,089; and Michigan, with 1,074.

Bachelor's degrees totaled 35,815, and the top five schools included Purdue, 945; Illinois, 754; Michigan, 615; Newark, 603; and Penn State, 578. Doctor's degrees in engineering totaled 2,303, and top schools were MIT, 173; Illinois, 114; California at Berkeley, 114; Stanford, 106; Purdue, 95; and Michigan, 74.

The national total for engineering master's degrees was 13,677, and the following schools topped the degree list: MIT, 696; Southern California, 509; Stanford, 508; California at Berkeley, 466; Purdue, 437; New York University, 420; Michigan, 385; Cornell, 336; and Illinois, 309. ◆

NOTEWORTHY WORK

Electronics and mathematics are being used to study music in University of Illinois research for which the Magnavox Company has contributed $10,000. Professor James W. Beauchamp of the Department of Electrical Engineering is seeking to discover the characteristics of tones which distinguish one musical instrument from another, and how tonal characteristics are affected by pitch, loudness, playing style, instrument model, and performer (see *Outlook,* June, 1966). Working with him is Professor Lejaren A. Hiller, Jr., of the School of Music, a pioneer in the application of electronics to music.

Beauchamp explains that a method for diagnosing poor tonal quality may help in the instruction of musicians, and that knowledge of what constitutes good quality may lead to improvements in conventional and electronic musical instruments. A thousand graphs have been recorded for each of seven instruments — trumpet, cornet, clarinet, flute, oboe, violin, and viola — and these are being analyzed with an electronic computer to pinpoint important properties of musical tones, and explore the causes of each instrument's unique tone qualities. ◆

Centennial Calendar

September 19-22 the Nuclear Ceramics Division of the American Ceramic Society will meet, bringing to the campus nearly one hundred engineers from industry, research institutes, national laboratories, and universities. Ceramic Engineering Professor A. W. Allen is in charge.

Engineering students will hold a symposium, "Engineering Education," on October 10. Featured will be a panel discussion on the topic, "The Role of Engineering in Society," and exhibits by various engineering societies. The symposium will be held in the Illini Union in Illini Rooms A, B, and C at a time to be announced. Theoretical and Applied Mechanics Professor J. O. Smith, chairman of the Centennial Observance Committee of the College of Engineering, is faculty coordinator.

The Department of Civil Engineering will hold a conference entitled "A Look Ahead into the Next Century of Civil Engineering Education and Practice" on November 9 and 10. The conference is part of dedication ceremonies for the new Civil Engineering Building, and will feature guest speakers and panel discussions of a variety of topics.

PEOPLE AND PLACES

Professor **J. A. Henry** of the Department of Mechanical and Industrial Engineering attended the National Technical Conference of the American Conference for Quality Control held in Chicago May 30 through June 2. He participated in a program on the teaching of statistical quality control and attended the meeting of the national board of directors. Professor Henry is the regional director for Illinois, Wisconsin, and Minnesota.

Professor **G. M. Sinclair** was recently selected to serve as chairman of the Metals Engineering Division of the American Society of Mechanical Engineers for the coming year. He was also selected to chair the Division conference on stress corrosion to be held in 1969.

G. R. Irwin, an Illinois alumnus who is known as the "Father of Fracture Mechanics," is one of the three editors of a new journal, *Engineering Fracture Mechanics.* Irwin has made major contributions to the technical fields of materials research and fracture mechanics. Professor **H. T. Corten** of the Department of Theoretical and Applied Mechanics will serve as an advisor to the journal, which will begin publication in January.

The twelfth C. C. Wiley Traveling Award in Highway Engineering was awarded to **Roger W. Wright**, a February U of I graduate in Civil Engineering. He traveled five thousand miles, from Canada to Florida, to visit highway projects and agencies. Wright was selected for his high scholastic standing, personal characteristics, and demonstrated interest and ability in highway engineering.

Arthur B. Chilton, Professor of both Nuclear and Civil Engineering, was recently elected to the post of vice-chairman of the Shielding Division of the American Nuclear Society. Another ANS post, membership on the Board of Directors of the Society's Educational Division, went to Nuclear Engineering Professor **George H. Miley.**

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
EDUCATION
PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NO. 8, OCTOBER 1967

In the order listed, this issue contains articles on the following subjects:

THE ILLINET COMPUTER NETWORK
A NEW MIDWESTERN RADIO TELESCOPE
RESEARCH TO HELP COMPUTERS UNDERSTAND SPEECH
THE FIFTH ANNUAL REVIEW OF ELECTRONICS
AN ASEE AWARD TO PROFESSOR SMITH

IF TWO HEADS ARE BETTER THAN ONE . . . .

A community of computers which help each other is being founded at the University of Illinois. What will become one of the nation's most powerful educational computer networks is being supported by a National Science Foundation grant of $850,000.

The system, called ILLINET, will solve many of the problems encountered with the increasing educational use of computers. Ordinarily, computing power is concentrated in one central system or decentralized via smaller machines located in departments which require data processing equipment. The massive volume of work a single system must handle often means large delays. With smaller, decentralized machines, the user loses access to the large system required for more complicated calculations. ILLINET will give the University the best of both — fast problem solving and massive computing power.

At the hub of ILLINET will be two powerful IBM System 360 computers, a Model 75 and a Model 50. The Model 50 will act as a master control unit, scheduling large-volume problems for the Model 75 and also processing some jobs itself, as time permits. Satellite computers located at various points on the campus will range from a small typewriter-like console which works directly with the central units to a large processor which will perform most calculations independently, relying on the larger system only when the job becomes too large.

ILLINET will allow its computers to assume many different roles. For example, an IBM 1800 now being installed in the Department of Chemistry will monitor and partly control certain kinds of experiments. Researchers there will control changing laboratory conditions while the machine provides immediate results of the experiment. Any analysis requiring computing capacity greater than that of the IBM 1800 could be switched through the ILLINET Model 50 to the Model 75, and the results returned quickly to the site of the experiment. Previously, researchers had to carry their data to the University's central computer and insert them in turn with other problems. With satellite computers and the backup power of ILLINET, the answers will begin to arrive while the experiment is still in progress. The quick reaction time of the system makes it an excellent experimenter.

The system has no foreseeable limits on its size, reach, or versatility. ILLIAC III, a pattern recognition computer being built at Illinois, is designed to search for, recognize, and analyze visual information. The flexibility of ILLINET will allow ILLIAC III to serve as its "eyes" or permit ILLINET to act as an expanded brain for ILLIAC III. Besides performing this function, ILLINET could serve distant users far removed from the University's campus. ◆

DISHING IT *IN*

A steerable listening device bigger than any yet aimed at space is being planned for the Midwest by a group of eleven universities with National Science Foundation support. A steerable radar telescope with a diameter one-third greater than the biggest now in existence, the sky-scanning dish may be as large as 360 feet in diameter, nearly double the area of the famous 240-foot instrument at Jodrell Bank in England.

Plans for its use include aeronomy, astronomy, meteorology, plasma physics, and space research. For these it would provide a Midwest facility comparable in importance to those in nuclear physics at Argonne National Laboratory or the planned accelerator at Weston. The telescope, however, would cost far less than either of these other installations.

Sponsoring the proposal is the Committee on Institutional Cooperation, established in 1958 by the Big Ten universities and the University of Chicago to facilitate

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the pooling of resources and talents on matters of mutual concern in higher education. The project centers in the Aeronomy Laboratory of the University of Illinois College of Engineering, under the direction of Electrical Engineering Professors Sidney A. Bowhill and John V. Evans.

The National Science Foundation recently made a $50,000 grant to the University of Illinois for preliminary studies and planning, augmenting an earlier grant for $51,000, though a decision whether to proceed with an engineering design has not yet been made.

The U of I has just awarded two contracts for engineering feasibility studies of the big radar telescope, either 328 feet in diameter, built in the open, or 360 feet in diameter, enclosed by some form of radome. Amman and Whitney of New York received a $19,000 contract for study of an open 100-meter instrument, and Rohr Corporation of Chula Vista, California, a $15,000 contract for study of a 10 per cent larger enclosed instrument. The engineering feasibility study is expected to be completed within a year, and construction to take three to five years.

The first purpose of the radar telescope would be for research in aeronomy — the study of the earth's upper atmosphere. This relatively new field studies the interaction between the ultraviolet rays of the sun and the molecules of the upper atmosphere. The rays dislodge electrons from molecules of atmospheric gases, producing charged particles which are scattered as trace elements through the ionosphere. Such things as the kinds and distribution of these charged particles, the chemical reactions that follow the ionization of particles, the balance between the rates of production and loss of such particles, and the character of the neutral atmosphere that surrounds them all appear to change as functions of the sunspot cycle. Other studies in this area yield information about the strange winds that move at high altitudes, the daily expansion and contraction of the atmosphere, and the geomagnetic "tail" that follows the earth on the night side.

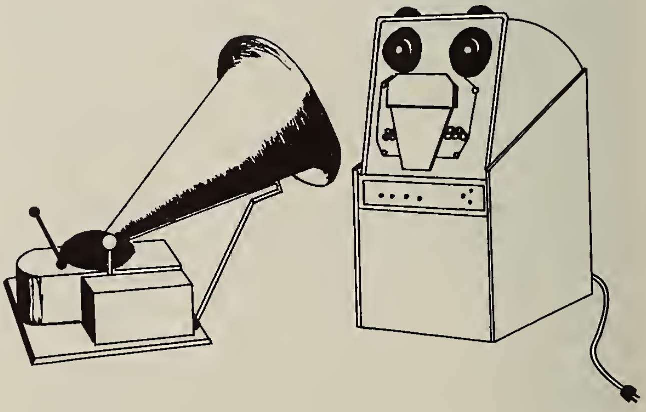
The new facility would complement rockets and satellites for ionosphere studies made at Illinois and elsewhere. Rockets can make short-duration, local measurements directly, and satellites can make long-duration global measurements of horizontal atmospheric variations at very high altitudes; the radar telescope can provide continuous scanning and can sweep a large area of the sky at one time.

Though its prime use would be for aeronomy, the telescope would also be capable of two other functions. It would have unprecedented capability for radar studies of Mercury, Venus, and Mars, gathering data about planets' surface features essential before any manned exploration. The instrument may also seek answers to questions about gravitation and the origin of the solar system.

The third capability of the proposed telescope is for radio astronomy — the study of radio signals originating in space. At present, some of the most exciting sources of cosmic noise are galaxy-like masses that appear to be exploding somewhere beyond the Milky Way. The radio signals they emit are far stronger than any produced on earth.

For deep space research, the Midwest would have available an instrument which can track and receive telemetry from space probes which government facilities are no longer tracking on a regular basis.

All the new telescope's research would provide opportunities for training graduate students. Construction and operation of the facility can strengthen ties between participating universities and their physics, astronomy, and electrical engineering departments. As a Midwest regional project, the facility overcomes both the prohibitive expense of such a radar telescope for one university and the isolation of a distant national laboratory. ◆



Even English is Greek to a computer. A machine may understand many languages — FORTRAN, ALGOL, MAD, or COBOL — but it can't make sense of the spoken word. Like others across the country, researchers in the University of Illinois Biological Computer Laboratory are trying to change that. The problem is a complex one: any system which will understand the spoken word must be insensitive to the volume of the speaker, his rate of speaking, and, within limits, his regional accent.

Traditional methods of studying speech break each word into sets of discrete frequencies which are examined separately. A sonagram provides a visual record of the duration and relative intensities of the frequencies which comprise the spoken word. It shows clearly defined patterns which recur when a word is voiced by different speakers.

U of I research assistant J. Gazdag has developed a processor which divides the word into twelve frequencies. Each of these is examined electronically, and a sequence of numbers corresponding to its intensity and duration is generated. While this sequence may vary from person to person speaking the same word, it is independent of volume or rate of speech.

Gazdag found that buried within these sequences were smaller sequences which were the same, independent of both the speaker and — to some extent — the pronunciation. The smaller, invariant sequences are decoded to render the word understandable by the computer.

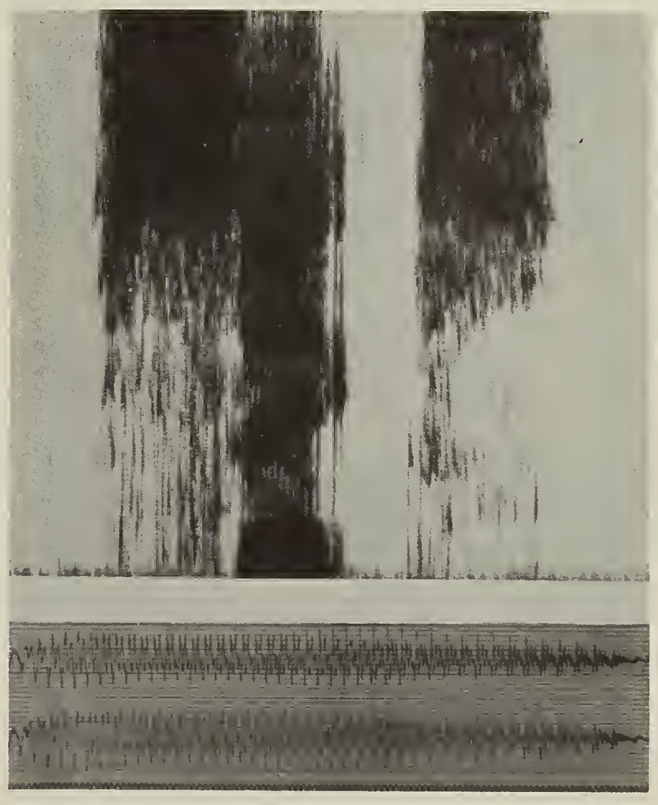
Biological Computer Laboratory engineers are also using a second approach to the task of decoding speech. Words travel as pressure waves in air. The initial part of a wave lasts only a few thousandths of a second, but contains nearly all of the information which identifies the vowel sound of the syllable. Analysis of the rapid changes in wave pressure could reveal the characteristics which allow the ear to distinguish words.

This represents a new approach to speech analysis, and may sidestep the problems of the frequency-analysis technique. Separating a word into its component frequencies distorts it, requiring an extensive and complicated study to distinguish between the original and the "noise" introduced in processing the word. Recording and analyzing the sound pressure wave allows the word to be captured *in vivo*. No additional complications are introduced.

Although present research centers about making the ten spoken digits recognizable to a special experimental machine, the future uses of a speech recognition system are broad: tomorrow might see meaningful, if dull, "conversation" with all types of hardware, using a generally accepted American vocabulary. ◆

FIFTH ANNUAL REVIEW OF ELECTRONICS SCHEDULED

The University of Illinois will hold its Fifth Annual Review of Electronics November 20-22, presenting the latest technical accomplishments of research in the Department of Electrical Engineering, Materials Research Laboratory, Coordinated Science Laboratory, and the Department of Computer Science. Short technical papers will be presented on solid state and quantum electronics, cybernetics and computers, and electromagnetics and plasma research. The conference, for researchers, development engineers, and technical managers in government and industry, will include laboratory visits and discussions with members of the University faculty. ◆



Two types of visible speech recordings are being studied by the Biological Computer Laboratory at the University of Illinois. The sonogram (top) of the word "six" shows the frequencies which are present in the word. The sound pressure graph (bottom) records the variations in air pressure for the same word. The research seeks to translate spoken language into terms understandable by computers and other machines.

SMITH GETS AN A AND FIVE C'S

Theoretical and Applied Mechanics Professor James O. Smith has received the Western Electric Fund Award of the Illinois-Indiana Section of the American Society for Engineering Education for his outstanding contributions to engineering teaching. In the award citation, Smith is recognized for "his outstanding service to students by instilling in them enthusiasm and inspiration for creative endeavor and intellectual development not only while in college but also throughout their careers, for his ability to create harmonious relations by exhibiting a warm and friendly attitude toward the student as an individual, for his active participation and leadership in the activities of professional societies, for his scholarly contributions to the permanent engineering literature, and for the profound influence his textbooks have had in the teaching of undergraduate and graduate students."

Smith is the first winner of the Award from the University of Illinois. The Award is given annually by each of the regional sections of ASEE and carries an accompanying gift of $500. ◆

Centennial Calendar

Engineering students will hold a symposium, "Engineering Education," on October 10. Featured will be a panel discussion on the topic, "The Role of Engineering in Society," and exhibits by various engineering societies. The symposium will be held in the Illini Union in Illini Rooms A, B, and C at a time to be announced. Theoretical and Applied Mechanics Professor J. O. Smith, chairman of the Centennial Observance Committee of the College of Engineering, is faculty coordinator.

The Department of Civil Engineering will hold a conference entitled "A Look Ahead into the Next Century of Civil Engineering Education and Practice" on November 9 and 10. The conference is part of dedication ceremonies for the new Civil Engineering Building, and will feature guest speakers and panel discussions of a variety of topics.

The Department of General Engineering will hold a Centennial Year alumni reunion, celebrating the forty-fifth year of the general engineering curriculum at Illinois. The celebration will include a special dinner on Friday evening, November 3, and a meeting during the morning of the fourth before the Dad's Day football game.

PEOPLE AND PLACES

The Illinois Society of Professional Engineers has honored Professor **C. Dale Greffe** with its Illinois Award for 1967. Professor Greffe was recognized for his "experience and support in the areas of education, consulting, and strong and continuous service to the society." He has served as president of the Illinois Society of Professional Engineers in 1963 and is currently a director of the National Society of Professional Engineers.

Aeronautical and Astronautical Engineering Professor **Harry H. Hilton** has been appointed to three-year terms on the National Academy of Sciences and the National Research Council on Basic Research. The new appointments continue his membership in both organizations.

Professor **James O. Curtis**, Department of Agricultural Engineering, has received the 1967 Metal Building Manufacturers Association Award for distinguished work in advancing the knowledge and science of farm buildings.

One stipulation of the award, which is presented by the American Society of Agricultural Engineers, is that a plaque shall be given to the institution from which the recipient received his bachelor's degree, in recognition of its contribution to the preparation of the individual for outstanding achievement. Curtis is a University of Illinois alumnus.

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ENGINEERING OUTLOOK
AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 8, NO. 9, NOVEMBER 1967

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In the order listed, this issue contains articles on the following subjects:

- RESEARCH ON SIMPLIFYING COMBINATIONS
- ENGINEERS' DEFINITIONS OF SUCCESS
- A NEW MEMORY-DISPLAY DEVICE
- A NOVEL MEETING AT THE U OF I

SIMPLIFYING SIMPLIFICATION

Ann loves Barbara, but can't stand Carol; Diane thinks that Ellen is charming, but that Ann is a bore; Barbara despises Ellen, but enjoys Ann's company. What is the largest number of girls who can get together under one roof for a party this weekend?

A hostess usually solves this problem by feminine intuition. When the same sort of problem occurs in electronic switching theory, intuition fails. In a modern computer, which may use the same circuit ten thousand times in solving a single problem, each circuit must be as simple as possible. In order to produce the simplest circuits, the computer designer must combine many input and output variables into related groups.

Present methods of discovering these groups are slow and unwieldy, requiring an item-by-item comparison to determine whether three items are combinable, and then searching the list to see if a fourth may be included in the group. This is especially time-consuming if the list is large.

A new technique developed by Coordinated Science Laboratory graduate student G. J. Lipovski presents an easily-used scheme of determining the largest combinable classes — the most girls who could be invited to the same party. His technique is also flexible enough to determine the largest groups which include certain given items — the largest guest list which includes Diane and Barbara.

More rapid in general than existing methods, Lipovski's new method is especially useful for combining many items. It might be used by a digital computer to design its own successor and, when combined with existing design methods, can lead to smaller, less complex computer circuits. ◆

THE SWEET, GREEN, PAPER-AND-INK SMELL OF SUCCESS

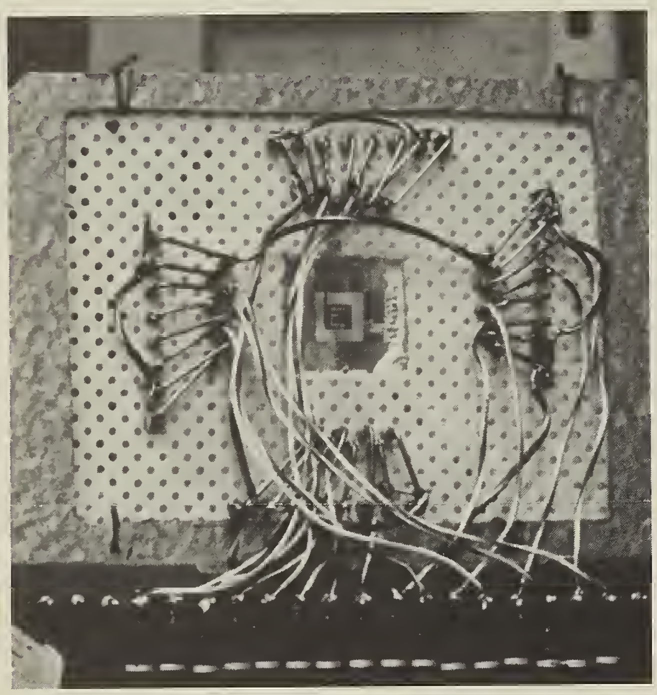
Ask an engineer to define "success" in his own words, and chances are good one of those words will be "money."

A group of 238 June engineering graduates, representing 12 disciplines and ages from twenty-one to forty-one years, described success in an attitude survey taken last February. While most of them used more than one word to say so, the consensus of the graduates was that having made it means having cash. Seven simply equated money with success. Only one man turned his back on wealth; he said that success "allows a person to work in the field which brings the most personal satisfaction — not necessarily the position which yields the greatest monetary reward."

Relatively few handed out the label of success to money alone. Some also wanted respect or prestige. Others insisted that good pay be coupled with power and high executive position. Many wistfully named happiness with themselves, their homes, their jobs, their families, and of course their pay scales, as an unmistakable sign of success.

In surprisingly similar answers, the engineers agreed that success meant enjoying their work. After receiving four to five years of training these graduates were anxious to contribute to society. But to meet the criteria for success, an engineer should be able to work in his own field of interest and have his accomplishments bring personal satisfaction. He should want to go to work, even on Monday mornings.

And if he's a success, according to these engineers, he'll show up for work bright and early on paydays as well. ◆



The Plasma Display Panel combines memory and display in a simple device. Developed under the direction of Professor D. L. Bitzer of the Coordinated Science Laboratory, the panel will provide an inexpensive display for the PLATO programmed teaching system of the University of Illinois.

SPOT-LIGHTS IN THE SPOTLIGHT

A novel display device invented in the University of Illinois Coordinated Science Laboratory has been named one of the 100 most significant industrial developments of the year by *Industrial Research* magazine. The U of I was honored for its invention September 19 at the fifth annual "I-R 100" competition in New York.

The Plasma Display Panel, invented by Coordinated Science Professor D. L. Bitzer, Research Engineer H. G. Slottow, and graduate student Bob Willson, is an electronic blackboard with a memory. The glass panel contains a closely spaced rectangular array of pinhole-sized cells filled with a luminescent gas. Grids of nearly invisible parallel electrodes cover both faces of the panel, vertically in front and horizontally in back, with insulated gas cells sandwiched between the electrodes where they cross. A voltage applied to two conductors causes the cell between them to glow with a tiny, but brilliant, light. The spots of light may be used to form words, diagrams, or pictures.

In addition to its display features, the panel also functions as a memory device. Each dot has two stable states, on and off. A cell which is "on" emits light only 3 to 5 per cent of the time, but changes so rapidly that it appears to glow continuously. It may be scanned by a computer and its state determined without disturbing the display. Individual cells may be turned on or off as quickly as one millionth of a second and, thanks to the rectangular arrangement of the panel, an entire row or block of cells may be illuminated or scanned simultaneously.

The panel was developed to provide an inexpensive display for PLATO, the computer-based teaching system currently in use at the U of I. Present display techniques using a television-type cathode ray tube require a "translator" to convert the computer's digital output into a form which may be used by the tube. The plasma panel will be cheaper and more compatible with the computer, thus eliminating the need for a translator.

Its inventors claim that the idea can be adapted to color presentation as well as black-and-white, and that large-scale mass production could reduce the panel's cost to a fraction of the price of present display systems. Because of its speed, potentially low cost, and memory features, the Plasma Display Panel should see use in a variety of applications. ◆

UNIVERSITY PLANS UNIQUE SYMPOSIUM

A Centennial Symposium scheduled at the University of Illinois November 29 to December 2 will bring scientists and humanists from throughout the United States to discuss science and the human condition. The Symposium is unique in that its participants will try to develop a basis for combining science and its implications with the humanities and social sciences.

Joel Snow, a fellow in the Center for Advanced Studies who is in charge of arranging the event, said the Symposium is being held because of a feeling in the U. S. that "there is a continuing need to refine and improve the teaching of science itself in all phases of general education."

Three keynote lectures to be given at the Symposium are designed to highlight the nature of the problems being studied and to illustrate their breadth and depth, Snow said. These lectures are open to the public.

The first lecture, "What Must a Responsible Citizen Know of Science?" will be given by Don K. Price, Dean of the John F. Kennedy School of Government at Harvard University. The second lecture, "The World of Science and the Scientist's World," will be given by Polykarp Kusch, a Nobel Prize winner in physics and a professor of physics at Columbia University. The third keynote address will be by Jacob Bronowski of the Salk Institute for Biological Studies. His topic is "Science as a Humanistic Discipline."

Students will also be included in the Symposium, attending the keynote lectures and participating in panel discussions. Participants from the Symposium will be invited to faculty homes, where they can meet with and talk to students.

Scientists and humanists who will participate in the Symposium include Gilberto Bernardini, former U of I professor and now president of the Italian Physical Society; Sidney Drell of Stanford University; Gerald Holton of Harvard University; Henry Margenau of Yale University; and W. Rife of North Central College. ◆

FOR THE NAVIGATORS OF SCIENCE: AN ATLAS

A new book for a new science is *Descriptive Inventory of the Arts and Sciences,* by Joseph T. Tykociner. *Inventory* has been published to complement *Outline of Zetetics* as a textbook for Professor Tykociner's course in zetetics at the University of Illinois — a course which, like the science of zetetics itself, was founded by Tykociner.

A major purpose of zetetics is to guide scientific research. As it has been described, "Science today is like a huge ship operated by many specialists, none of whom is navigator." Zetetics would train "navigators" for science, men who could consider the best circumstances for creativity and the most productive scheduling of problems to be solved.

Descriptive Inventory of the Arts and Sciences furnishes an organized compilation of nearly all branches of human endeavor. It would be useful to the library scientist as well as the student of zetetics. It is available from the Engineering Publications Office, with checks made payable to Joseph T. Tykociner, for $3.00. *Outline of Zetetics, A Study of Research and Artistic Activity,* is also available for $2.00. ◆

ORDER FORM FOR NEW PUBLICATIONS

☐ Bulletin 492, *Factors Influencing the Plasticity and Strength of Lime-Soil Mixtures,* by Marshall R. Thompson. *$3.00.*

☐ Bulletin 493, *Investigation of Prestressed Reinforced Concrete for Highway Bridges, Part IV: Strength in Shear of Beams with Web Reinforcement,* by S. Ø. Olesen, M. A. Sozen, and C. P. Siess. *$3.00.*

The following Bulletins have been reprinted and are again available:

☐ Bulletin 304, *A Distribution Procedure for the Analysis of Slabs Continuous over Flexible Beams,* by N. M. Newmark. 1938. *$1.00.*

☐ Bulletin 332, *Analyses of Skew Slabs,* by V. P. Jensen. 1941. *$1.00.*

☐ Bulletin 369, *Studies of Highway Skew Slab-Bridges with Curbs: Part I — Results of Analyses,* by V. P. Jensen. 1947. *$1.00.*

☐ Bulletin 414, *Frequency Analysis of Hydrologic Data with Special Application to Rainfall Intensities,* by Ven Te Chow. 1953. *$1.00.*

☐ Bulletin 462, *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins,* by Ven Te Chow. 1962. *$1.50.*

The popular "Civil Engineering Studies Construction Research" series has been continued with the following new publications:

☐ CRS 9, *A Man-Machine CPM System for Decision-Making in the Construction Industry,* by A. C. Brooks, J. P. Leahy, and L. R. Shaffer. *$3.00.*

☐ CRS 10, *A Network Approach to Resource Scheduling,* by L. S. Zimmerman and L. R. Shaffer. *$3.00.*

Other new publications:

☐ *Men and Ideas in Engineering,* by Elisabeth Schillinger, Rudy Berg, and Alan Kingery. This book, published by the University of Illinois Press, relates twelve stories of projects from the 100-year history of the U of I College of Engineering. *$5.00* plus 25c tax.

☐ *A Summary of Engineering Research, 1967. No charge.*

☐ Proceedings of the Ninth Sanitary Engineering Conference, *Instrumentation, Control, and Automation for Water Supply and Wastewater Treatment Systems. $4.00.*

☐ Catalog, *A Listing of Engineering Publications, 1904-1967. No charge.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

Send with remittance to Engineering Publications, 112 Engineering Hall, Urbana, Illinois 61801.

GENUINE STIRLING

Table of Stirling Numbers of the Second Kind, by Alex M. Andrew with an introduction by Heinz Von Foerster, is available from the Engineering Publications Office at a cost of $2.00. The table lists Stirling numbers, $S(n,k)$, less than $10^{109}-1$ for values of n and k up to 100.

Stirling numbers find their largest use in combinatorics — the basic foundation of probability theory. They occur in such widely different areas as thermodynamics and linguistics. Prepared at the Biological Computer Laboratory, this is the first listing to such accuracy — 109 digits. ◆

PEOPLE AND PLACES

Ven Te Chow, Professor of Hydraulic Engineering, University of Illinois Department of Civil Engineering, has been requested by the government of Brazil and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) to assist the Brazilian government in establishing a "Centre for Applied Hydrology" with financial assistance from the United Nations Development Programme.

The principal functions of the Centre will be to train specialists in appropriate aspects of applied hydrology at both the graduate and undergraduate levels and to engage in research and planning of water resources projects.

Edwin L. Goldwasser, Professor of Physics at the University of Illinois, has been named deputy director of the National Accelerator Laboratory to be located at Weston, Illinois. His appointment, which took effect July 1, was announced by the Universities Research Association (URA) in Washington, D.C.

As deputy director, Goldwasser will be involved in planning the experimental facilities and research program; he will also assist in the administration of the laboratory.

Daniel Alpert, Dean of the Graduate College will serve as chairman of a study of science, engineering, and regional economic development for the National Academy of Sciences and the National Academy of Engineering.

Dean Alpert will help establish a committee that will study the impact of science and engineering upon regional development, and the effects of federal scientific and technical policies upon regional development. The committee is to make recommendations for balanced regional growth. The Office of Regional Economic Development of the Department of Commerce has requested the science and engineering academies to undertake the study.

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH

EDUCATION

PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 68, NO. 10 · DECEMBER 1967

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In the order listed, this issue contains articles on the following subjects:

CIVIL ENGINEERING'S CENTENNIAL AT ILLINOIS
RESEARCH ON REMOVING VIRUSES FROM DRINKING WATER
AN UNDERGRADUATE COURSE CONCERNED WITH HUMANITY
A NEW U OF I FACILITY FOR FINDING INFORMATION

100 YEARS OLD, AND NEVER STRONGER

Last year Nathan M. Newmark, head of the University of Illinois Department of Civil Engineering, said in his annual report that "The Department is in a position to assume national leadership in the field of civil engineering . . . [to become] first in the nation."

Only a month before, the American Council on Education survey of the nation's graduate programs in science and engineering rated the Department second among all departments of civil engineering in the nation.

With quality goes size. Illinois is one of the top schools of the country in number of full-time undergraduate and graduate students in civil engineering. This fall the Department has 512 undergraduate and 279 graduate students. Graduate students are attracted from all over the world and are an elite group, for only the best can be admitted. The U of I leads the nation in total doctorate degrees conferred in civil engineering. One of every six civil engineering Ph.D.'s in America earned his degree at Urbana.

A feature of this department is its flexibility and encouragement of younger men in developing new ideas. There is no separation of research, graduate, and undergraduate teaching. Newmark, as Department head, makes a special point of the contact between senior staff members and undergraduate students. All senior staff members teach undergraduate classes and advise undergraduate students.

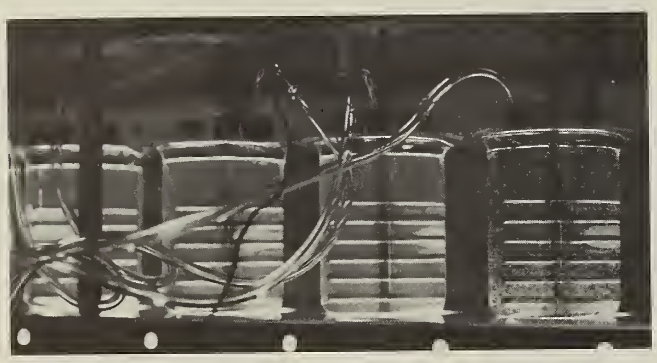
Five members of the faculty — professors William P. Ackermann, Don U. Deere, Chester P. Siess, Newmark, and Ralph B. Peck — have been elected to the National Academy of Engineering. Newmark was a founding member of this academy, and has been honored also by election to the National Academy of Sciences and the American Academy of Arts and Sciences.

Civil engineering was one of the original areas of teaching in the University indicated by the planning committee in 1867. When the University opened in 1868, civil engineering was largely a matter of roads, structures, and surveying. Today the Department is involved in structural analysis and design, sanitary and hydraulic engineering, water resources, soil and rock mechanics, transportation and traffic engineering, photogrammetry, and systems engineering.

Department research involves $2 million a year, at least three-fourths of which comes from outside the University. Sponsors include federal and state agencies, technical societies, professional associations, research councils, and private industry. In their thesis research, graduate students work on research projects with staff members. Undergraduate students also may obtain research experience through an optional program.

Research follows a pattern of analysis and theory, proof through application in both laboratory and field studies, and then taking results to the profession through publications, short courses, activity in professional organizations, and through graduates who carry the latest information direct from campus to job.

This fall the Department — for the first time in its century-long history — has a building of its own, taking several expanding areas out of temporary quarters and bringing them together. In many areas research is in connection with other fields — soil mechanics has spread into oceanography, sanitary engineering to biology, photogrammetry to space science, systems into electronic computers, and structures and soils into nuclear engineering — pointing the way toward even wider travels for this distinguished group of engineers. ◆



Coagulation-flocculation, a chemical reaction useful in clearing suspended particles from water, is shown at work in the beaker on the right. University of Illinois Sanitary Engineering Professor R. S. Engelbrecht is directing an investigation of flocculation as a way to remove viruses from drinking water.

A FLOC OF VIRUSES

The virus is the Mr. In Between of the animate-inanimate world. Whether the virus is a living organism or just a complex protein molecule is a matter of debate. One fact isn't: many viruses cause serious infectious diseases in man.

Treatment, especially chlorination, of public water supplies has sharply reduced the threat of bacterial waterborne disease. But viruses are more resistant to chlorine, so the problem that viral disease might be spread by public water supplies is still serious. The commonest way to remove the threat is by removing the viruses from the water.

At the University of Illinois, Sanitary Engineering Professor R. S. Engelbrecht and research assistant Malay Chaudhuri are working to understand how coagulation-flocculation — a process used to clear water of suspended matter — works against viruses, and how it can be made more effective. The general workings of flocculation are understood: a coagulant (usually a metallic salt) added to water containing suspended particles cancels the electrical repulsion which keeps the particles suspended, allowing them to settle; flocculation, a further aggregation of these particles, draws them together into larger masses which are easier to remove from the water. Engelbrecht and Chaudhuri have hypothesized, from new knowledge about protein chemistry, that when viruses are present the metallic coagulant and viruses form a protein-metal ion complex which, like a concrete overcoat, drags the viruses to the bottom.

The engineers' first studies examined the effects of pH and temperature on a bacterial virus, to insure that reductions in the virus population in later stages of the project were due to flocculation, and not from water temperature or acidity changes from the flocculation reaction. Future studies will use animal viruses with protein characteristics like those of polio and infectious hepatitis viruses — the ultimate targets of the work.

Engelbrecht and Chaudhuri are among the few men expert in both virology and water treatment technology. They hope that, by studying the basic mechanism of this kind of virus removal, they can find ways to modify existing treatment systems for better virus removal. An added hope is that knowing better what *can* be done to remove viruses will lead to more accurate water treatment standards specifying what *must* be done. ◆

ENGINEERING FOR MAN

The engineer of the future — regardless of his special interests — should be provided with a fuller and richer understanding of the social and economic forces that will influence and be influenced by his technology. — Interim Report of the American Society for Engineering Education Committee on Goals of Engineering

The College of Engineering of the University of Illinois has met this challenge with a novel response: Engineering Systems Design Project 1, a systems approach to the problems of the blind, offered as a special course by the James Scholars Program in Engineering. The year-long study will provide experience in the design of complex systems. Undergraduate students from a variety of fields will examine the interaction of the blind with society, and consider the design of a system to widen the blind's perception of the world.

The class will examine characteristics of blindness from social, physical, economic, psychological, and medical viewpoints, beginning with the physical process of vision and other means of perception. The actual design project will be chosen by the class after several months of consideration. The result may be an educational system for blind children, a navigation and location device, or an information gathering and transmitting system.

Staff members and off-campus specialists will lecture and be available to the group as consultants and advisors. Technicians, typists, and draftsmen will provide technical support for the class.

Since there are few texts in the area of systems design, the case study is an effective method of teaching. It allows the student to participate actively in the structure of the course, even determining what is to be learned. By attacking an existing problem in a realistic way, students learn from the best instructor — experience.

The systems approach provides a basis for communication between the various disciplines. The seventeen students enrolled represent the areas of electrical engineering, sociology, physics, psychology, and aeronautical engineering. They must work together to produce a system which is technically correct, socially workable, and psychologically acceptable to the blind.

Electrical Engineering Professor Heinz von Foerster established the tone of the course when he spoke at the first class meeting: "I believe the engineer is, in fact, extremely able in dealing with the problems of man in society. However, tradition has not allowed him to do that. We are all members of society, and we must all consider Man." ◆

WHAT'S BLACK AND WHITE AND LOST ALL OVER?

When the weight of the paperwork equals the weight of the equipment, the project is complete. — Old Engineering Folksaying

The information explosion sounds suspiciously like the rustling of tons and tons of paper — punctuated by the anguished cries of people looking for the facts they need. In engineering, today's research may require the results of work completed only a few months ago. It is difficult to find a reference to the appropriate report, and almost impossible to locate the report itself. It might be located through its author, his department, his sponsor, or — more likely — not at all.

The College of Engineering at the University of Illinois is trying a new solution to this problem: the Engineering Documents Center, a central clearinghouse which collects, catalogs, and locates reports from the College, and searches and orders reports from other sources.

Reports from Illinois are indexed alphabetically by title, author, laboratory, and sponsoring agency, in a newly compiled cumulative index which will be available in departmental offices in January. This index makes available more than two thousand reports from the College, including complete historical collections from the Departments of Electrical Engineering and Theoretical and Applied Mechanics. Collections of recent reports of other departments are also available.

As guides for outside sources of information, a variety of government bibliographies are available, such as those from the Atomic Energy Commission, National Aeronautics and Space Administration, and the Clearinghouse for Federal Scientific and Technical Information. The Documents Center can assist with information relating to projects in progress throughout the U.S. through its affiliation with the Scientific Information Exchange of the Smithsonian Institution. Personnel at the Center can provide assistance and coordination with any of these agencies.

The Engineering Documents Center may be the researcher's most useful and convenient ally when he needs information at the University of Illinois. It's certain that he can use the help. ◆

COORDINATED SCIENCE LABORATORY DEDICATED WITH SYMPOSIUM

A two-day symposium on "The Interaction of Science and Technology" highlighted dedication ceremonies of the Coordinated Science Laboratory, a new federally supported three-million-dollar structure on the Urbana-Champaign campus.

James E. Webb, administrator of the National Aeronautics and Space Administration, spoke at a luncheon following formal dedication ceremonies October 17. Trustee Donald R. Grimes of Chicago represented the Board of Trustees.

NASA provided a grant of $1,125,000 for Space Science Center facilities in the building, which is equipped with research laboratories, offices, a 200-seat seminar room, and specialized facilities. Research in the Laboratory, which began in 1951 as the Control Systems Laboratory, now involves $1,750,000 per year in support from non-state sources. ◆

Technicion Sally Blazic, analyzing the composition of o chemical solution, injects it beneoth the flame of an atomic absorption spectrometer. This spectrometer, which utilizes a laser, is one of a group of precision analytic devices under study by University of Illinois Professor V. G. Mossotti of the Materials Research Laborotory to measure chemical imperfections in materials.

TENTH SANITARY ENGINEERING CONFERENCE PLANNED

"Waste Disposal from Water and Wastewater Treatment Processes" is the title of the Tenth Sanitary Engineering Conference to be held at the University of Illinois on February 6 and 7. The Conference is planned for sanitary engineers in government, industry, or private practice, and water works managers and operators. The Division of Sanitary Engineering, Illinois Department of Public Health, and the U of I Department of Civil Engineering are the joint sponsors. Further information may be obtained from Professor John H. Austin, 3230 Civil Engineering Building, University of Illinois, Urbana, Illinois 61801. ◆

EASTMAN CONTINUES GRANTS TO CHEMISTRY AND PHYSICS

Unrestricted grants by the Eastman Kodak Co. of $10,000 each to the Department of Chemistry and Chemical Engineering and to the Department of Physics bring to a total of $145,000 received by the University of Illinois from this company in a program inaugurated in 1962.

The two departments were among 37 selected graduate departments in colleges and universities assisted by Eastman for the encouragement of graduate education and research. ◆

PEOPLE AND PLACES

The U.S. Surgeon General has appointed Civil Engineering Professor **Richard S. Engelbrecht** to the engineering and urban health sciences study section of the National Center for Urban and Industrial Health. The section advises the Center of research needs in its field, and reviews training and research grant applications dealing with environmental health. Engelbrecht was appointed for four years and will serve as chairman of the section.

Professor **John E. Baerwald** of the Department of Civil Engineering has been named technical vice-president of the International Institute of Traffic Engineers.

The University of Liege, Belgium, conferred an honorary doctoral degree upon Civil Engineering Department head **Nathan M. Newmark** November 6, in recognition of Newmark's "outstanding contributions in the field of applied sciences."

Hillel Poritsky, visiting professor in the U of I Theoretical and Applied Mechanics Department, received the Timoshenko Medal from the Applied Mechanics Division of the American Society of Mechanical Engineers at the Society's annual meeting in Pittsburgh on November 14. The medal was awarded to Poritsky to honor his distinguished contributions to his field. He has been a pioneer in applying analytical methods to complex problems in industrial equipment, and many of his new methods of analysis have gained world-wide acceptance. His most recent emphasis has been on studies of rotor instability and the factors contributing to these instabilities.

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 9, NO. 1, JANUARY 1968

In the order listed, this issue contains articles on the following subjects:

A NOVEL METHOD OF PREDICTING GAS BEHAVIOR
A U OF I INSTITUTE ON COMPUTERIZED EDUCATION
ENGINEERING HELP FOR MENTAL HEALTH RESEARCH
A COMPUTER ASSISTANCE PROGRAM FOR CONTRACTORS

ELECTRONIC BUMP-'EM

Dates arranged by computer make headlines these days, but a different kind of computerized encounter interests researchers at the University of Illinois. The Rarefied Gas Dynamics Group of the Coordinated Science Laboratory has its eye on computer-simulated collisions between gas molecules — millions of them — as a technique for solving a long-standing problem in predicting the behavior of gases.

How a gas behaves is determined by the motion of its molecules. With a complex mathematical relation known as the Boltzmann equation, researchers can predict this behavior — but one especially sticky portion of the equation defied evaluation for nearly eighty years.

Ten years ago, U of I physicist Arnold Nordsieck developed a special "Monte Carlo" method as a way past this obstacle. He was helped, as many modern scientists and engineers have been, by the computer. It was established long ago that the molecules of a gas collide at random, and that knowing the details of a sample of these collisions would provide a good indication of what the entire body of molecules was doing. Nordsieck used the computer to arrange a collision between two fictional molecules whose velocities and angle of collision were picked at random, and to compute the resulting molecular velocities. The speed of the computer made it possible to repeat this process millions of times — without requiring lifetimes of human calculations — for a fair sample of the behavior of the gas.

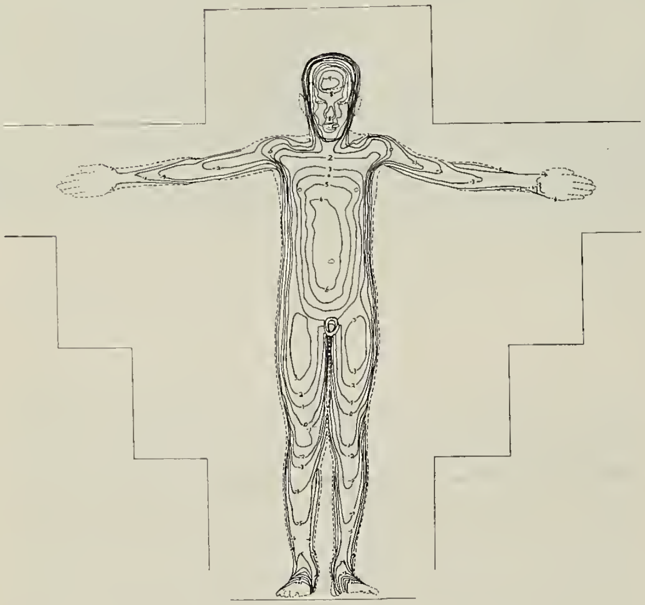
Many of the more difficult problems of gas dynamics involve situations which are far from equilibrium. The behavior of the molecules may vary widely from one place to another within the gas, and previous methods were unable to cope with local variations in the characteristics of the gas. But the computer can predict these unusual characteristics and can, for example, give a detailed description of a strong shock wave within the gas.

The Rarefied Gas Dynamics Group, working under the direction of Professor Bruce Hicks of the Coordinated Science Laboratory, conducted a Workshop on Monte Carlo Solutions of the Boltzmann equation at Urbana, November 1-3. A select group of scientists were shown the technique which, though widely applicable in gas dynamics, is not well known to researchers outside the University. But as developments like the SST and space flight focus attention on the problems of high-speed aerodynamics and atmospheric re-entry, the Monte Carlo method is likely to find greater use — perhaps ironically, to reduce the designers' gamble. ◆

TWELVE PEOPLE, ONE MACHINE: PLATONIC

A dozen educators from across the nation participated in an eight-week institute this summer at the University of Illinois to discover the potentials of computer-based instruction. The institute was conducted at the Computer-based Education Research Laboratory through a $41,000 grant from U.S. Office of Education.

The group first learned in detail how to use CERL's PLATO computerized teaching system, and was introduced to much of the work which has been done with PLATO in past years. Later, individuals or small groups chose topics they wanted to teach, chose methods for teaching them, and practiced programming PLATO to teach with those methods. The PLATO system, developed at the University's Coordinated Science Laboratory, has received national attention as a possible mechanism for alleviating much of the drudgery in the teacher's role. ◆



Contour maps such as this are prepared in an unusual study by civil engineering research associate Simha Weissman and Professor H. M. Karara. The maps, made from three-dimensional photographs of mentally retarded children, are being used to investigate the relationship between body shape and mental condition.

MAPS TO MENTAL HEALTH

A map which may lead to better mental health is being produced by researchers at the University of Illinois. Their project brings an unusual innovation — aerial surveying techniques — to a study of mentally disturbed children.

Experts have noted an apparent correlation between a child's body shape and his mental condition, but theories have been hard to test because many precise measurements are required, and mentally disturbed children are often uncooperative and difficult to measure. Now Professor R. E. Herron, Director of the Motor Performance Laboratory of the U of I Children's Research Center, and research associate Simha Weissman and Professor H. M. Karara of the U of I Department of Civil Engineering, have developed a quick and accurate solution to the problem: photograph the child simultaneously from the front and rear with stereometric (3-D) cameras.

The child stands, his hands outstretched, within a plywood frame which serves as a reference plane for the cameras. The photographs can be analyzed for accurate data on body surface area and volume. The photographic data can be handled digitally, to construct a mathematical model of the child's body, or can be used to produce contour maps which are accurate to within half an inch. Perhaps the feature which is most important in making the system practical is speed: the child must remain motionless for only a few seconds.

The system of measuring contours with stereo cameras is commonly used for aerial reconnaissance and mapmaking, and is finding use as a no-contact distance measuring technique at short ranges.

Information from the photographic study is being used by Herron, who hopes to correlate body size and shape with mental state. Ultimately such findings may be used to diagnose and possibly predict mental retardation, and perhaps detect and treat disturbances in younger children. ◆

AUTOMATION FOR WATER SUPPLY SYSTEMS

New concepts in instrumentation, control, and automation were presented in 13 talks at the Ninth Sanitary Engineering Conference held last February at the University of Illinois under the sponsorship of the Illinois State Department of Public Health, Division of Sanitary Engineering, and the U of I Department of Civil Engineering, in cooperation with the Division of University Extension.

The proceedings of the Conference, *Instrumentation, Control, and Automation for Water Supply and Wastewater Treatment Systems,* published in June, are intended to help design engineers, managers, and operating personnel of water supply and wastewater treatment systems to decide what methods and hardware are available for carrying out economical engineering operations. The proceedings may be purchased at $4.00 from the Engineering Publications Office. ◆

RESEARCH SUMMARY PUBLISHED

The *Summary of Engineering Research 1967,* a complete description of engineering research at the University of Illinois during the past year, has been published. Over 600 projects are listed with sponsors, investigators, and publications resulting from the research. The *Summary* provides a useful reference to current work in the College for faculty members, graduate students, and researchers in industry and at other universities. It is available from the Engineering Publications Office. ◆

$50,700 NSF GRANT FOR RADIO ASTRONOMY

A $50,700 grant from the National Science Foundation will finance improved electronic handling of data from radio sources far out in space. The signals are received by the University's radio telescope at the Vermilion River Observatory near Danville. The NSF funds will provide additional apparatus for recording data and processing it in a computer in the Department of Electrical Engineering. An earlier $24,500 NSF grant provided the equipment now used. ◆

COMPUTER ON CALL

The "computer revolution" will enter a new field starting February in a project between the construction industry, consulting engineers, and the University of Illinois.

Professors L. R. Shaffer and S. J. Fenves, cochairmen of the Civil Engineering Systems Laboratory, will have an opportunity to try out on actual problems the theories and programs they have been working on for five years to speed decision-making and planning in the construction industry.

The project is in the University's Department of Civil Engineering, and is supported by the U.S. Department of Commerce under the State Technical Services Act, with matching funds from the University and contractors. After a general announcement of plans last year, 15 contractors and consulting engineers in 11 cities signed up to receive the benefits of a high-speed electronic computer without leaving their offices. The program will handle estimating, planning and scheduling, payroll and cost accounting, and structural analysis.

An electric typewriter in each contractor's office will transmit data to the campus at Urbana, where it will be fed into an electronic computer. The computer's output will go back to the originating office.

One example of the computer's job is in the extensive calculations required in estimating a job. The computer won't do it all; data for a quarter-million-dollar building will still require several days to assemble. But when this data is fed into the properly programmed computer, the machine will do the calculations in two minutes. This demonstration of modern computational technology for the construction industry will develop programs and methods which will become public property for general use. At the same time the cooperating contractors will receive benefits valuable in a highly competitive industry. ◆

NEW SCHOLARSHIPS ESTABLISHED

Twenty-four new industry-sponsored scholarships valued at a total of $11,150 have been established at the University of Illinois for students in metallurgical engineering, Professor Charles A. Wert, head of the Department of Mining, Metallurgy, and Petroleum Engineering, has announced.

Six industries, supporting one to four scholarships each, are backing eighteen of the new awards, and six scholarships are through a fund supported by five firms. Most of the scholarships are for new students and will be awarded on a basis of scholarship and professional promise rather than financial need. ◆

Professors L. R. Shoffer (standing) and S. J. Fenves, cochoirmen of the Civil Engineering Systems Laboratory ot the University of Illinois, ore developing plans to use high-speed electronic computers to speed decision-making and planning in the construction industry.

UNIVERSITY OF ILLINOIS COOPERATES IN WATER STUDIES

The University of Illinois and Southern Illinois University will cooperate in a laboratory investigation into water research. The four-part project is supported by a grant of $102,000 by the U.S. Department of the Interior, to be matched by state funds under the terms of the Water Resources Research Act of 1965.

Two of the four projects in the study will be conducted at Urbana. W. H. C. Maxwell, Assistant Professor of Civil Engineering, will study "Boundary Effects on Jet Flow Patterns Related to Water Quality and Pollution Problems"; and Earl R. Swanson, Professor of Agricultural Economics, will undertake an "Economic Analysis of Water Use in Illinois Agriculture." ◆

GOOD LOOKING GIFT

Some gifts bear examining more than others, but a new present to the U of I Coordinated Science Laboratory is really getting the twice-over. It should: The gift is an electron microscope.

Presented by Varian Associates, of Palo Alto, California, the new instrument is valued at about $12,000, and is capable of resolving images smaller than one hundred millionth of an inch. The microscope is also exceptionally easy to operate.

The instrument is being used by CSL Professors Norman Peacock and Franklin Propst for research on material surfaces, especially the surface structure of evaporated thin films — an area of increasing interest in electronics and physics. ◆

U OF I REMAINS A LEADER IN ENGINEERING GRADUATES

Among the 99 members of the National Association of State Universities and Land-Grant Colleges, the University of Illinois has remained a leader in the number of graduates on all levels of engineering education, the Office of Institutional Research reports.

Using 1965-66 statistics for the Urbana-Champaign campus from the U.S. Office of Education, the Association ranked the University second in number of bachelor's degrees granted for the year with 754, sixth in master's degrees with 309, and tied for second in doctoral degrees with 114.

Purdue University leads at the bachelor's level with 945 degrees, followed by Illinois, Georgia Tech, and Michigan. Top listings at the master's level are Massachusetts Institute of Technology, California, Purdue, Michigan, Cornell, and Illinois. For doctorates, MIT is first with 173 degrees. The University of California (Berkeley) and the University of Illinois follow with the same number, 114. ◆

PEOPLE AND PLACES

The Education Medal of the Institute of Electrical and Electronics Engineers will be awarded to **Edward C. Jordan,** head of the Department of Electrical Engineering in the University of Illinois. The Medal will be presented March 20 at the annual banquet of the IEEE International Convention in New York, according to Donald G. Fink, general manager of the Institute.

Jordan is being cited "for leadership in bringing new technological developments into electrical engineering education, and in creating an integration of research with education in a major department." He has been at Illinois since 1945, and Electrical Engineering Department head since 1954. He is the second faculty man from Illinois to receive the Education Medal. In 1957 it went to Dean **William L. Everitt** of the College of Engineering.

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

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In the order listed, this issue contains articles on the following subjects:

- MESSAGES ON A BEAM OF LIGHT
- A STUDY OF GAMMA RADIATION SHIELDING
- GRANTS FROM THE NATIONAL SCIENCE FOUNDATION AND UNION CARBIDE
- ILLINOIS AS AN NSF RECIPIENT
- A NEW ARMY RESEARCH LABORATORY

SAY SOMETHING BRIGHT

Once upon a time, a message on a wave meant a note in a bottle. Not today, though, for every message on radio or television travels on a wave of the electromagnetic variety.

As the world sends more messages, the need grows for ways to send information more concisely and efficiently. A solution under study by researchers at the University of Illinois has an information capacity nearly a million times as great as that of radio.

Since crowding more information onto a wave requires a wave of higher frequency, Electrical Engineering professors D. F. Holshouser and O. L. Gaddy have chosen a wave of such high frequency that it isn't normally thought of as a communication wave: they are using light. Light's ultra-ultra-high frequency allows information to be transmitted at a much greater rate than conventional radio techniques permit.

The U of I engineers' light source, the laser, is particularly well suited for the job. Its light is nearly all the same frequency and is easily focused into a narrow, efficient beam. Ordinary light contains a broad spectrum of frequencies and is more difficult to focus. Ordinary light, too, is unpolarized, without any particular orientation other than its direction of travel. The laser's beam can be conveniently polarized, so that it varies in only one direction, as though its rays were composed of parallel ribbons of light.

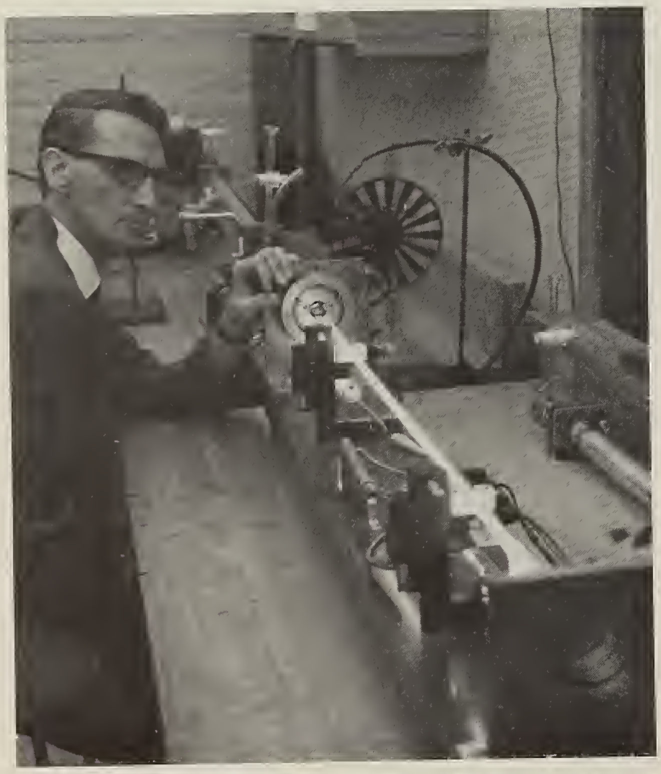
Sending information with the laser, as Holshouser and Gaddy are doing it, involves an electro-optical device called a Kerr cell. When the beam passes through the cell, the light's polarization is altered by an electrical signal applied to the cell. The electrical signal, which contains the information to be transmitted, thus passes it on to the light beam.

The light from the cell shines on an analyzer, a kind of optical picket fence. When the ribbons of the polarized light are aligned with the slots in the fence (the optical axis of the analyzer), the wave passes through the analyzer with maximum intensity. As the wave's polarization changes, less of the beam gets through the analyzer, and the emerging light's intensity decreases. Thus the Kerr cell changes the polarization, and the analyzer translates these polarization changes into variations in intensity. As a result, the information from the electrical signal is impressed on the light beam as a series of extremely rapid changes in the beam's intensity.

At the receiving end of the system, the beam signal must be translated back into an electrical message. At ordinary low frequencies, changes in light intensity can be detected by a conventional photomultiplier, which converts the light into electrical signals. Incoming light strikes a light-sensitive metal which emits electrons. These electrons travel a short distance and strike a target which emits more electrons. This process is repeated several times, with an increasing number of electrons at each step, until the incoming light signal is converted to an amplified electrical signal.

The electrons in the photomultiplier, however, do not travel at exactly the same speed. At low frequencies, this difference is not noticeable. As the frequency of the incoming signal increases, the difference in travel time becomes more apparent: electrons which were released together spread out, distorting the input signal. Holshouser and Gaddy developed a newer type of photomultiplier which bunches the electrons and forces them to travel the length of the tube in unison. A high-frequency signal applied to the detector speeds the slower electrons and slows the faster ones, keeping the electrical signal clear and undistorted.

Although present research is concerned only with the basic problem of packing the greatest amount of information into the least amount of time, the research may point the way to future communications systems. Since the laser light cannot penetrate clouds, the TV of the future may come to the viewer via "light pipes" which will direct the signal down their length, avoiding interference from external sources. Then when viewers sit down to "watch the tube," they'll mean it. ◆



A Kerr cell and a new kind of photomultiplier developed at the University of Illinois are elements in research exploring microwave-frequency communication via beams of laser light. Professors D. F. Holshouser and O. L. Gaddy are directing the project. Holshouser here examines the system's microwave frequency modulator.

CHILTON TO STUDY RADIATION SHIELDING

Arthur B. Chilton, Professor of both Nuclear and Civil Engineering, has been awarded an $11,700 grant by the National Science Foundation to carry out "Monte Carlo Studies of the Effects of Polarization, Electron Binding and Coherent Scattering of Gamma Ray Albedo and Penetration." At a theoretical level this study will investigate the effects of gamma radiation on the occupants of nuclear fallout shelters in terms of radiation exposure and absorbed dose of radiation. ◆

NSF GRANTS FOR TECHNOLOGY INSTITUTES

Grants for $134,820 and $64,000, respectively, from the National Science Foundation will provide funds for the Fifth Academic Year Institute for Engineering Technology Teachers and the Eighth Summer Institute in Engineering Technology for College Teachers at the University of Illinois.

Professor Jerry S. Dobrovolny, head of the Department of General Engineering, is director of the Institutes. Each year fifteen teachers from junior colleges and technical institutes participate in the Academic Year Institute and 40 teachers attend the Summer Institute. The programs have been pioneered at Illinois. ◆

UNION CARBIDE GIVES $33,000 TO U OF I

Grants totaling $33,000 have been made to the University and six departments through the university relations department of Union Carbide Corporation. They include $5,000 each to the Department of Chemistry, Division of Chemical Engineering, Department of Electrical Engineering, Department of Mechanical Engineering, Department of Mining, Metallurgical and Petroleum Engineering, and Department of Physics, and $2,250 to the University for scholarships and $750 for miscellaneous use. ◆

NSF GRANT FOR UNDERGRADUATE RESEARCH

Eight juniors and seniors in the University of Illinois Department of Civil Engineering will be offered special opportunities for independent research under an $11,200 National Science Foundation grant just announced. The money provides financial assistance to students during winter semesters and full-time support in the summer session. NSF and Department funds also pay for equipment and other costs, according to Professor Richard N. Wright, who is in charge of the program.

The program, which began in 1959, gives undergraduates the opportunity to become acquainted with research and to decide more ably at graduation whether to enter fields of engineering research or applied engineering. Research projects may be anything in civil engineering in which a student is specially interested. Each student has a faculty supervisor available for guidance, but is encouraged to work as independently as possible.

Since the program began, 85 students have taken part. Of those who have been graduated, three-fourths have gone on to advanced study, Wright said. He noted that similar, though less intensive, experience is gained by many other students through part-time work on Departmental research, which in civil engineering at the U of I involves nearly two million dollars a year. ◆

U OF I AMONG FIRST 20 IN NSF INSTITUTIONAL GRANTS

The University of Illinois ranked fourteenth overall and ninth among state colleges and universities participating in the National Science Foundation's Grants for Sciences in 1967.

Through this program, the University received $145,500. The allocation is based on the amount of grants received by faculty members at the institutions for basic research projects. In 1967, 517 colleges and universities participated in the $15.15 million program.

The highest 20 are University of Chicago, Columbia, University of California at Berkeley, Harvard, Massachusetts Institute of Technology, Cornell, University of California at San Diego, University of Washington, Stanford, Michigan, University of California at Los Angeles, Pennsylvania, Wisconsin, Illinois, Yale, Princeton, Purdue, Indiana, Minnesota, and Ohio State.

The range of awards among the first 20 was from $159,200 to the University of Chicago down to $136,800 to Ohio State University. ◆

ARMY CONSTRUCTION RESEARCH LAB DETAILS DISCLOSED

Details of contracts involving $3.25 million for the Army Corps of Engineers Construction Research Laboratory, to be built near the University of Illinois at Urbana-Champaign, have been announced. The announcement came jointly from Herbert O. Farber, treasurer of the University of Illinois Foundation, and Lieutenant General William F. Cassidy, chief of the Army Corps of Engineers in Washington. Cassidy also announced that Lieutenant Colonel Rodney E. Cox, who holds a Ph.D. in engineering, has been named director of the Laboratory.

The Laboratory's site is the Interstate Research Park in northwest Champaign, three miles from the University campus. The Army selected this location so that the Laboratory can draw on the University's engineers and authorities in many other fields. To the University, the Laboratory is advantageous for instructional and research programs, especially in engineering. General Cassidy said, when the site was chosen, that the location near the University of Illinois was selected after careful study of proposals from twenty engineering schools and universities. He noted rapid advances in technology and more stringent demands for performance of the facilities needed for construction, saying that these require increased research.

Professor Nathan M. Newmark, head of the Department of Civil Engineering at Illinois, said, "There will be strong interaction between the University and the research laboratory in training programs and thesis work."

Three and one-quarter million dollars in contracts have been let for a new Army Corps of Engineers Construction Research Laboratory, to be located in Champaign near the University of Illinois. A strong and mutually beneficial interaction is anticipated between Laboratory and University engineers.

He said that the Laboratory's programs would present numerous research possibilities for students in civil, mechanical, chemical, metallurgical, and ceramic engineering, and also in geology and agricultural engineering.

The Laboratory announcement noted that three contracts have been signed which involve buildings with 100,500 square feet of space to be completed early in 1969 on 15 acres of land. Expansion planned in future construction through early 1973 will increase the facility to 260,360 square feet on 30 acres.

The University of Illinois Foundation will finance the project through a loan to be repaid through rentals from the Corps of Engineers. Ultimately the property may be transferred to the University of Illinois. ◆

NEW BULLETIN DESCRIBES STRESS BEHAVIOR

Engineering Experiment Station Bulletin No. 494, *Stress Concentration at External Notches in Members Subjected to Axial Loadings*, by A. T. Derecho and W. H. Munse, analyzes the effects of external notch geometry on stress concentrations in axially loaded members. Of interest to structural engineers in a variety of fields, the Bulletin is available for $3.00 from the Engineering Publications Office. ◆

REPRINTS AVAILABLE

Two popular Engineering Experiment Station Bulletins have been reprinted and are available from the Engineering Publications Office. Bulletin 462, *Hydrologic Determination of Waterway Areas for the Design of Drainage Structures in Small Drainage Basins*, by Ven Te Chow, and Bulletin 304, *A Distribution Procedure for the Analysis of Slabs Continuous over Flexible Beams*, by N. M. Newmark, are available at a price of $1.50 for Bulletin 462, and $1.00 for Bulletin 304. ◆

PEOPLE AND PLACES

Professor **Jerry S. Dobrovolny**, head of the Department of General Engineering, has been elected president of the American Technical Education Association. Dobrovolny has served as an advisor on technical education to the federal and state governments and to junior colleges in Illinois and elsewhere, and for seven years has directed summer institutes and academic year programs in engineering technology held at Urbana-Champaign under the auspices of the National Science Foundation.

The Professional Progress Award in Chemical Engineering for 1967 went to Professor **Thomas J. Hanratty** of the Department of Chemical Engineering. The Award is given by the American Institute of Chemical Engineers to men under forty-five years of age who have made significant contributions to the science of chemical engineering by original work in developing a new process, producing a theoretical discovery or invention, or by rendering a distinguished service to chemical engineering.

Professor **Edward C. Jordan**, head of the Department of Electrical Engineering, has been awarded the Education Medal of the Institute of Electrical and Electronics Engineers. The Medal will be presented March 20, 1968, at the annual banquet of the Institute's international convention in New York City. Jordan has been at the University since 1945 and Department head since 1954.

Professor **Eugene I. Radzimovsky**, Department of Mechanical and Industrial Engineering, has been elected as a fellow of the Shevchenko Scientific Society, the highest Ukranian scientific society in the Free World. Radzimovsky was elected to the mathematics and natural sciences section.

Professor **John Bardeen** will assume the presidency of the American Physical Society during its January 29–February 1 meeting in Chicago. Bardeen has been a member of the University's physics and electrical engineering faculties since 1951, and also is a member of the University's Center for Advanced Study.

In 1956 he shared the Nobel Prize as co-inventor of the transistor, and since has received wide acclaim for the B-C-S theory explaining superconductivity. He received the National Medal of Science in 1965 and has received numerous other honors.

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ENGINEERING OUTLOOK

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 9, NO. 3, MARCH 1968

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UNIVERSITY OF ILLINOIS

In the order listed, this issue contains articles on the following subjects:

WIND TUNNEL SIMULATION OF GROUND EFFECT
SEPARATING STORM AND SANITARY SEWAGE
RECORDING THE SHAPE OF TEST WELDS
ADVANCED COMPUTER GRAPHICS SYSTEMS
A MICROSCOPIC FLUID MECHANICS STUDY
AWARDS FOR STUDENTS, TEACHERS, AND ALUMNI

WIND TUNNEL TESTS ABOVE THE BELT

Despite admen's fantasies about airborne autos, the place for a car is *terra firma* — and, as Walt Kelly has put it, the more firmer, the less terror. As their speeds increase, keeping cars on the road isn't easy. The Ford Motor Company discovered this fact painfully in the design of its GT40 race car. Wind tunnel tests at the University of Maryland indicated that the car was aerodynamically almost perfect; when the car was road tested, however, it handled badly at high speeds. Measurements indicated that at 130 mph there was as much as 1100 lbs. of lift at the car's front axle.

Now a project in the University of Illinois Department of Aeronautical and Astronautical Engineering may make these kinds of wind tunnel tests more dependable. In a conventional wind tunnel, air is blown over a stationary model and roadway. Since the model roadway is static, a boundary layer of slow-moving air forms near it. In reality, both air and road move at the same speed relative to a traveling auto. The difference in the air speeds under the test model and actual car is subtle but significant.

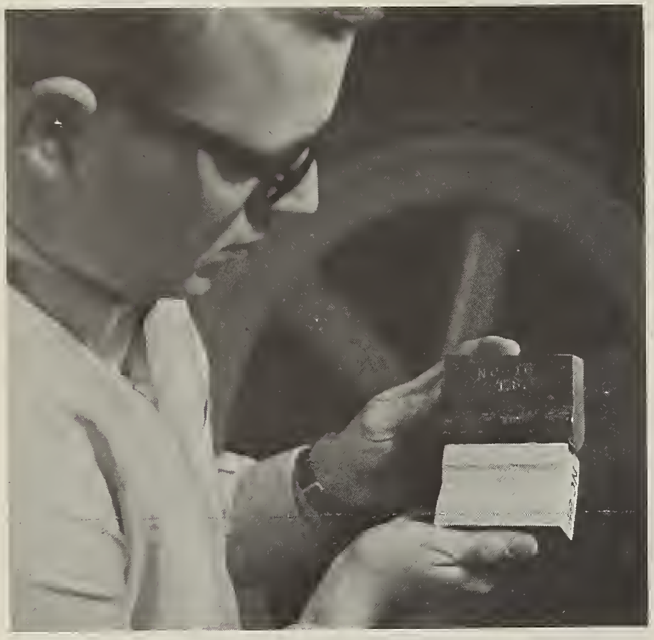
In order to minimize the effect of the wind tunnel boundary layer, R. H. Liebeck and his assistants, William Bradshaw, John Busby, and Carl Swain, have worked out a technique that replaces the stationary floor of the wind tunnel with a moving belt. The belt, moving at approximately the same velocity as the air, provides the same effect as still air and still ground under a traveling car, and so simulates more accurately how a car will actually perform on the road. The new technique may also improve tests of the takeoff and landing characteristics of aircraft, and simulate the environments of such low-level vehicles as hovercraft. ◆

SEGREGATED SEWAGE

The flea on the fly on the bird on the branch on the tree in the hole in the ground may be fun to sing about, but it's trivial compared to the sewage in the pipe in the sewage in the pipe under study by University of Illinois Professor J. M. Robertson.

The idea makes sense. In many sewage systems, pipelines must carry rain water during storms in addition to the sanitary sewage they ordinarily handle. Sewage disposal plants, however, can't keep up with the total volume during storm periods, so they bypass some of the mixture directly to streams, thereby polluting them. One remedy for this situation is to keep the two kinds of sewage separated. But building new and separate systems would be costly; it would be less expensive, where pipelines are large enough for workers to enter them, to insert small pipes for sanitary sewage into the larger existing networks, leaving the remainder for storm sewage.

Robertson's work has checked the reduction in capacity of the larger pipe resulting from this kind of insertion. He has uncovered some interesting subtleties: moving a small pipe from the center to the side of a large one, for instance, can reduce the restriction by half. Part of a large-scale study, the Combined Sewer Separation Project of the American Society of Civil Engineers, Professor Robertson's project in the U of I Department of Theoretical and Applied Mechanics exemplifies the important role of engineers in facing the critical problems of water pollution. ◆



A welded joint, and a cast made to record its unbroken shape, are displayed by University of Illinois research assistant Harlan Stauffer, who is engaged in a weld fatigue project directed by Civil Engineering Professor W. H. Munse. The research, which seeks to relate weld shape to fatigue strength, uses casts such as these to provide accurate permanent records of welds which are destroyed in the tests.

JOINT: A PLACE TO GET PLASTERED

Wisdom may come out of the mouths of babes, but a clever idea has come out of the mouths of dentists' patients. At the University of Illinois, a plaster-like material ordinarily used for dental casts is recording the unbroken shape of test welds later shattered in research.

A study of the failure of welded joints under repeated loads is closely related to the problem of building durable bridges. The study is being sponsored by the Illinois Division of Highways and the U.S. Bureau of Public Roads. Civil Engineering Professor W. H. Munse is directing special weld-fatigue research which simulates the repetitive load conditions of bridge joints, and seeks to relate the fatigue strength of welds to their shape. A simple cast made of each joint captures its three-dimensional geometry accurately and quickly, and the cast can be filed for future reference after the weld itself is broken.

After a welded specimen is subjected to repeated loads and broken, its cast is sliced and measured at the point where the crack started. The civil engineering researchers hope to uncover consistent relationships between the weld shape and durability, and use these as guidelines for quality control and inspection of welds which will be subjected to repeated loads. Through criteria such as these, engineers can insure that bridges and other welded structures will last as long as they should. ◆

BRUSH TOO HEAVY? USE A LIGHT PEN

Lots of people have drawn on television for new ideas, but researchers at the University of Illinois Department of Computer Science have gone them one better. Perhaps two better. They're *literally* drawing on television, and they're doing it in color.

The Hardware Systems Group, directed by Professor W. J. Poppelbaum, is turning the television tube into an artist's canvas, with the help of a novel hybrid computer system. Their setup combines the analog computer's dexterity with pictorial information and the digital computer's speed and accuracy. Using hybrid circuits, Poppelbaum's group has designed simple, self-contained processors which work without the help of an additional digital computer, and which can process information in ways that would be impossible with either analog or digital circuits alone.

The group's interest in graphical data-processing started with the knowledge that computers might be useful for a variety of tasks involving the creation or analysis of pictures: fingerprint identification, handwriting analysis, pictorial intelligence gathering, map-making, sketching and drafting for engineering or architecture, and deciphering photographic data from astronomy or nuclear physics are just a few of the obvious applications.

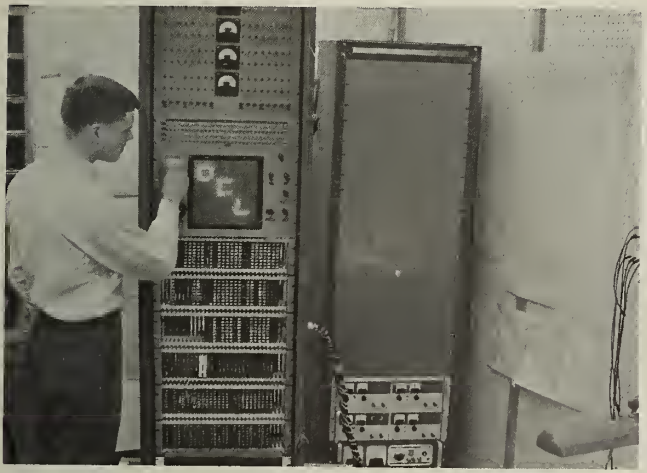
Paramatrix was the result of the group's first efforts to build a graphical processor. In it, information on a photographic slide was sensed by an electronic scanner and displayed on a rectangular array of tiny lights. The pattern could be electronically moved, rotated, or enlarged, and retouched to remove cloudiness or fill in gaps in its lines.

A more advanced graphical processor, the Artrix system, incorporates some features which eliminate much of the drudgery of drafting: it can automatically connect two points with a straight line, or draw a circle of specified radius around any point selected as center.

This system was designed to incorporate a television monitor as an input and display unit. With a light pen, the Artrix user can "draw" patterns directly on the face of the picture tube. The fast processing time of the system (about one-thirtieth of a second) makes the image appear almost instantaneously on the screen.

With Artrix, the only obvious deficiency was color. To supply this element, the Illinois group is building a Tricolor Cartograph, using a color TV monitor and incorporating all the capabilities of Artrix. In addition, its hybrid circuits will enable it to fill in areas of the drawing with colors: all the operator need do is specify which one or two or three of the primary colors he wants, and indicate with the light pen the area to be colored.

Hybrid circuits are especially essential for this colorful feature. Purely digital circuits, for instance, could locate the areas to be colored only after considerable time and effort. With hybrid circuits, though, an area can be completely colored in a few tenths of a second. Artrix, Paramatrix, and the Tricolor Cartograph are probably just the first manifestations of the Hardware Systems Group's activities: hybrid circuits and other advances show promise for future applications which include ultra-cheap computers. ◆



The Paramatrix system was the first of a series of graphical processors developed by the Digital Computer Laboratory at the University of Illinois. The display, being adjusted by research assistant Edward Carr, produces a picture which can be rotated, enlarged, or moved electronically.

THINK THIN

Anyone who ever needed a safety pin knows that the little things in life can be important. In the expanding field of fluid mechanics, many of the most important mysteries involve an extremely small region near the boundary of a turbulent flow. The mechanisms of friction, heat transfer, and turbulence in pipes and channels are intimately related to the fluid behavior in the "viscous sublayer." This region, however, is too thin to permit the use of standard measuring techniques, so progress in exploring it has been slow.

At the University of Illinois, Civil Engineering Professor H. G. Wenzel is directing a research project, under the sponsorship of the Water Resources Center, which takes a literally microscopic look at this tiny but important region. A powerful microscope, coupled to a high-speed motion picture camera, is used to map the detailed flow structure of the viscous sublayer in a small glass open channel. Pictures taken at speeds up to five thousand frames per second are then analyzed frame by frame to determine the instantaneous speeds of very small polystyrene tracer particles suspended in water — and find, as well, the speed of the water at those points.

Analysis of the pictures, although tedious and time-consuming, shows considerable promise as a way through the complexities of such important but little understood phenomena as turbulence in the viscous sublayer. If turbulence is better understood, friction can be more accurately determined in a pipe or channel, or over a watershed. This knowledge will in turn guide engineers in the design of the many kinds of projects involving the flow of fluids through or over surfaces. ◆

STUDENTS, ALUMNI, TEACHERS TO BE HONORED

At the fourth annual honor awards convocation of the U of I College of Engineering, to be held May 2, four students will receive special awards; four teachers will receive the first Everitt Undergraduate Teaching Excellence awards; and five alumni will be honored for their outstanding services to, or achievements in, engineering.

This year's student winners are John L. Welch, senior in electrical engineering, Hamilton Watch Company Award; Peter Worcester, senior in physics, Lisle Abbott Rose Memorial Award; Robert H. Rossen, senior in chemical engineering, Harvey H. Jordan Award; and Donald A. Hanson, junior in electrical engineering, Honeywell Award.

The teachers to be honored are James Bayne, Associate Professor of Mechanical Engineering; John P. Gordon, instructor in electrical engineering; Wallace M. Lansford, Professor of Theoretical and Applied Mechanics; and Shung-Wu Lee, Assistant Professor of Electrical Engineering.

Recipients of the alumni honor awards are H. E. Babbitt, Professor Emeritus of Sanitary Engineering at the University of Illinois, for his national and international leadership in educating sanitary engineers and for his contributions to sanitary engineering; Glenn Murphy, Distinguished Professor and Head of Nuclear Engineering at Iowa State University, for his innovative contributions to engineering education; W. E. Ogle, Test Division Leader, Los Alamos Scientific Laboratory, for his distinguished patriotic service to the nation in the field of nuclear weapon technology and nuclear rocket propulsion; R. J. Rutherford, President of the American Gas Association and President of the Worcester Gas Light Company, for outstanding contributions in pioneering, developing, and furthering cooperative research in the gas industry; and F. S. Wells, Vice-President, Stephens Adamson Manufacturing Company, for his successful and distinguished career in the materials handling industry, for the fostering of young engineers in the industry, and for his untiring civic activities.

R. J. Rutherford will present the convocation address, and W. L. Everitt, Dean of the College of Engineering, will present the awards. ◆

TENTH SANITARY ENGINEERING CONFERENCE

The increasingly urgent topic of pollution was discussed by thirteen speakers at the tenth Sanitary Engineering Conference, *Waste Disposal from Water and Wastewater Treatment Processes,* February 6 and 7. The conference gave a wide coverage of the subject, beginning with an outline of the problem by keynote speaker H. E. Hudson, Jr., of Hazen and Sawyer Engineers in New York City, continuing with various treatment processes, utilization of usable products, and costs involved, and closed with an editor's view into the future of water and wastewater treatment, presented by George E. Symons, editor of *Water and Wastes Engineering* magazine.

The conference had a record attendance of 287 participants, mainly from municipal waterworks authorities, the consultant firms, and the manufacturing companies. The proceedings of the conference will be published May 1, 1968, and will be available from the Engineering Publications Office at $4.00 per copy. ◆

PEOPLE AND PLACES

Dean **Daniel Alpert** of the U of I Graduate College is one of 15 leading scientists, engineers, and administrators named to three-year terms on the advisory board of *Industrial Research* magazine. Professor **John Bardeen,** of the Department of Physics, the Department of Electrical Engineering, and the Center for Advanced Study, is now completing a three-year term on the publication's advisory board.

The director of the Highway Traffic Safety Center at Urbana, Civil Engineering Professor **John E. Baerwald,** has been honored a second time for a paper prepared for the Pan American Highway Congress, recently held in Montevideo, Uruguay. He was presented with a special award certificate. His first honor came at the group's meeting in Washington in 1963. Baerwald's papers were screened by every nation in the Congress before acceptance.

Professor **Arthur L. Friedberg,** head of the Department of Ceramic Engineering, has been named chairman of the engineering panel of the National Science Foundation postdoctoral fellowships program. Last year he was a member of the panel. His appointment was announced by the National Research Council of the National Academy of Sciences and National Academy of Engineering.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 9, NO. 4, APRIL 1968

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In the order listed, this issue contains articles on the following subjects:

COMPUTERS AND ENGINEERING EDUCATION
A NEW BROAD-BAND ANTENNA
AN ENGINEER INCOME SURVEY
AN AWARDS PROGRAM TO HONOR WAYNE A. JOHNSTON
GRANTS TO THE U OF I FROM NSF AND THE AIR FORCE

A STOP-ACTION PORTRAIT: COMPUTERS AND ENGINEERING EDUCATION AT ILLINOIS

> *The ways in which we have done things traditionally are not the ways in which they should be done to take advantage of the fact that there is a computer. The kind of things that one learns, the algorithms and so forth, are different for an approach that does not use a computer compared to one that does, and a complete reorganization of the engineering curriculum is one of the things that we must face in the future.*
>
> —N. M. Newmark, head of the University of Illinois Department of Civil Engineering

As early as 1946 engineers, mathematicians, and physicists were at work to provide the University of Illinois with computing facilities. The formalization of this interest in 1949 with the organization of the Digital Computer Laboratory, later to become the Department of Computer Science, marked the beginning of a period of rapid and important change for engineering education at Illinois.

The first major impact of computing on undergraduate study in engineering came in 1961, when a basic course in programming was first offered as an elective. The following year this course became a required part of the curriculum for a handful of departments, and by 1966 a basic course in programming was required for every engineering undergraduate. Presently each year approximately 1500 students receive this kind of acquaintance with computing.

About half the University's engineering undergraduates proceed beyond this basic course to one or more of the dozen advanced courses offered in computer science. Courses in every engineering curriculum require that the undergraduate develop a real working ability to use the computer as part of his class work.

At the graduate level, involvement with the computer often means using, even creating, techniques and equipment which are as advanced as those to be found anywhere. One graduate student in three in the Department of Computer Science is working toward an advanced degree in some field of engineering. Several members of this department hold joint appointments in engineering departments as well, and serve as advisors for graduate students with engineering backgrounds or interests.

Engineering education at another level, for contractors and consulting engineers, is one of the functions of the University's Civil Engineering Systems Laboratory. The Laboratory develops computer approaches to engineers' and contractors' problems, and trains both students and graduate engineers in these approaches.

Seven digital computer systems are operated in the College itself, and it is indicative of the sophistication of the University engineers' needs that this assortment includes some of the most advanced commercially produced machines now available. Fourteen analog computers are also in use within the College of Engineering, primarily for instruction rather than research.

In addition to these facilities, but accessible for a variety of research, educational, and service uses, are the machines of the Department of Computer Science. Among the most interesting computers soon to operate at Illinois are ILLIAC III, a novel new computer with pattern-recognition capability, and ILLIAC IV, a large parallel processing computer which will be the fastest in the world. Equally promising in terms of educational uses will be the ILLINET computer network, now under construction, which will link a number of computers on the engineering campus and elsewhere into a system which provides both the fast service common to local computers and the massive computing power available from a large central machine.

Perhaps the most unusual applications of computers to engineering education at Illinois involve the PLATO computer teaching system developed in the Coordinated Science Laboratory of the College of Engineering. Now the heart of the new computer-based Education Research Laboratory, the PLATO hardware consists of a central computer connected to specially designed student carrels. Special sections of an advanced undergraduate course in linear network theory, the first college-credit course ever "taught" entirely by computer, have been offered for several semesters, and an electrical engineering honors course for undergraduates is using PLATO, with audio and braille typewriter hookups, in a student-designed project to develop a system for teaching the blind. ◆

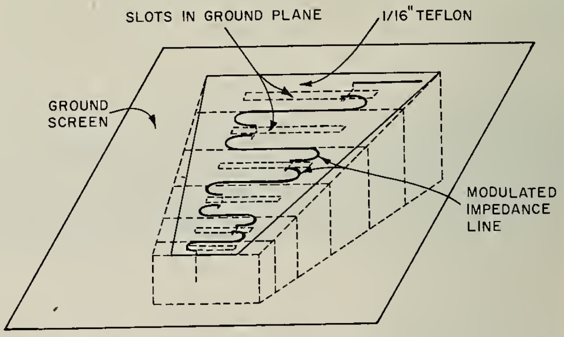
DO YOU READ ME, WILBUR?

If the Wright brothers' airplane had carried radio, its antenna could not have caused many aerodynamic problems: A hat rack tied on with string would have stayed put at those speeds, and hat rack streamlining would have been quite in character for the Wright *Flier*.

Today, of course, it's another story. Supersonic speeds mean that airborne antennas have to be as sturdy and unobtrusive as possible, despite the fact that they also have to handle a wider range of radio frequencies than ever before. Plastic radomes and streamlined antenna covers, the common solutions to this problem, are an unhappy compromise. They interfere with antenna performance and clutter up an airplane's streamlining.

At the University of Illinois, electrical engineers have come up with a new antenna that may make both radio men and aerodynamicists happy. It consists mainly of a series of graduated slots in the skin of the aircraft, and can cover an extremely wide band of frequencies.

The slot antenna, developed during World War II, is nothing new. Ordinarily a single slot is limited, as most other simple antennas are, to a narrow range of frequencies. U of I research assistant Paul Ingerson and Professor Paul Mayes modified the slot antenna concept, however, in a project sponsored by the Air Force Avionics Laboratory of Wright-Patterson Air Force Base. They used the principles of logarithmic-periodic scaling — a system for joining simple antennas of various frequency ranges into a more versatile combination.



This log-periodic slot antenna, developed by University of Illinois Electrical Engineering Professor Paul Mayes and research assistant Paul Ingerson, shows promise as a streamlined antenna for high-speed aircraft. The antenna can be mounted entirely flush with the aircraft's skin and is capable of operating over a wide range of frequencies.

This part of the engineers' work produced an antenna design which was fairly obvious: a series of increasingly large slots, backed by a series of similarly graduated cavities which would shield the interior of the aircraft from the radio signals generated by the antenna. At this point, it looked as though the problem of producing a streamlined wide-band antenna had been solved.

Not quite. When the slots were connected to a single transmitter or receiver, something went wrong. Ingerson set up a similar situation as a problem for a computer, and found the basic difficulty: between the transmitter and the slot most active at any one frequency was a region, caused by the other slots, which reflected most of the power back toward its source, choking the antenna.

The researchers finally eliminated the reflection by altering the connection from the transmitter to the slots so that the properties of the connecting line itself changed sharply near each slot. With this modification, the new antenna worked beautifully. Further computer analysis and laboratory work have indicated that the antenna's clever hookup will find use not only with slot antennas in aircraft, but in a variety of other log-periodic antennas as well — probably first in those used for high-frequency communications. ◆

AIR FORCE RENEWS THREE RESEARCH GRANTS WITH $142,708

The U. S. Air Force Office of Scientific Research has renewed three research grants to the University of Illinois with a total of $142,708. For research titled "Charged Colloidal Particles for Propulsion," under Electrical Engineering Professor Charles D. Hendricks, the grant is $38,583; for work titled "Relations Between Logical Structure, Time, and Natural Numbers," under Electrical Engineering Professor Gotthard Gunther, $47,922; and for "Complex Analysis," research under Professor Lee A. Rubel of the Department of Mathematics, $6,203. ◆

NEWS FROM THE FIVE AND TEN

Income for University of Illinois engineering graduates of ten years ago has increased 157 per cent over their starting pay in 1957, and for graduates of five years ago it is up 70 per cent over their salaries in 1962. Graduates of 1957 now average $1,227 a month, compared to $477 when they started work, and 1962 graduates average $968, compared to $571 when they started, according to reports on graduates of five and ten years ago compiled by Mrs. Pauline V. Chapman, placement director for the College of Engineering. Starting salaries have risen 51 per cent since 1957 and 26 per cent since 1962: last June, engineering graduates from Illinois began work at an average of $723 a month.

Employment in Illinois is bringing back some of the younger U of I engineers. While 34 per cent of the class of 1962 had their first jobs in the state, now 40 per cent are here. Of the class of 1957, Illinois now is the home of 37 per cent. By comparison, of last June's graduates, 48 per cent went to jobs in Illinois.

More than half of the graduates of 1962 are with their first employer, while 33 per cent have made one change; 12 per cent, two; and 3 per cent, three changes. Of 1957's graduates, 39 per cent are with their first employer 10 years later, 27 per cent have made one change; 19 per cent, two; 12 per cent, three; 3 per cent, four or more changes.

Among graduates of 1957, the biggest average salary gain is in physics, up from $484 to $1,374 in ten years — 184 per cent. Many of these have earned advanced degrees, and today the physics graduates average better pay than any of their engineering classmates.

For the class of 1962, graduates in engineering mechanics show the biggest gain, from $549 to $1,053 — 92 per cent — and now are top in their class. ◆

NSF CONTINUES ADVANCED TRAINEESHIP GRANTS

A grant of $741,822 to the University by the National Science Foundation is aimed at accelerating the output of students with advanced degrees in science, mathematics, and engineering. The grant will support 135 year-long graduate traineeships and 23 summer traineeships for teaching assistants. It will be administered by Professor Vincent I. West, associate dean of the Graduate College.

West announced that 58 new graduate traineeships will be awarded for study starting next fall, and 23 for study this summer. The graduate traineeships are renewable up to four years. In the five years of the NSF project's operation, the University has received $2,692,000 for graduate traineeships. ◆

JOHNSTON MEMORIAL AWARDS PROGRAM ANNOUNCED

A memorial awards program honoring the late Wayne A. Johnston, long-time president of the Illinois Central Railroad, has been established by the railroad at the University of Illinois. Mr. Johnston was president of the University's Board of Trustees when he died last December.

Annual awards will total $3,600, said University President David D. Henry. The Wayne A. Johnston Memorial Awards Program will start in September, and will give two undergraduate students and one graduate student each $1,200. They will be selected by the University, with preference to sons and daughters of Illinois Central employees. One undergraduate is to be in the transportation option of the Civil Engineering Department in the College of Engineering, the other in the transportation option of the Department of Economics in the College of Commerce and Business Administration. The graduate student may be in either of the two fields.

President William B. Johnson of the Illinois Central said, "It is our expectation to renew this grant annually as a fitting memorial to the contributions of Wayne Johnston to the University and to the transportation industry."

Johnston, a native of Champaign County, attended the University with the Class of 1919. While he was a student, he began working for the railroad in 1918 as an accountant. He became president of Illinois Central in 1945, relinquished these duties in 1966 to become chairman of the board of the railroad and of Illinois Central Industries, and retired last November at the age of seventy. He was elected to the University of Illinois board of trustees in 1951 and was nearing the close of his third six-year term when he died. He was active in civic organizations and especially interested in the Boy Scouts, from whom he received the highest national awards.

President Henry cited Johnston for his "deep feeling — for friends and family, for church and school, for his railroad and the business system which allowed him and his company to prosper" and his "deep and abiding devotion to his community, his state and country." ◆

GRANT $94,800 FOR SAFETY STRUCTURE RESEARCH

The U of I Department of Civil Engineering has received a $94,800 National Science Foundation grant to support research that will develop technical concepts and methods of probabilistic structural mechanics important in safety predictions for structures and systems.

Director of the project is Professor Alfredo Ang of the Department of Civil Engineering; Professor Mohammed Amin and C. C. Tung, also in civil engineering, will cooperate in the work. ◆

BRIDGE STUDY BULLETINS AVAILABLE

The distribution of moments and deflections produced by moving vehicles in model multigirder bridges is discussed in a new Engineering Experiment Station Bulletin. Bulletin No. 495, *Model Studies of the Dynamic Response of a Multigirder Highway Bridge,* by W. H. Walker, is the third in a series of closely related highway bridge dynamics studies. The previous two were Bulletin No. 489, *Response of Three-Span Continuous Highway Bridges to Moving Vehicles,* by J. S. Nieto-Ramirez and A. S. Veletsos, and Bulletin No. 486, *Response of Simple-Span Highway Bridges to Moving Vehicles,* by W. H. Walker and A. S. Veletsos. Bulletins No. 495 ($4.00), No. 489 ($3.00), and No. 486 ($4.00) are available from the Engineering Publications Office. ◆

PEOPLE AND PLACES

Three members of the University of Illinois electrical engineering faculty were honored in New York at the awards banquet of the Institute of Electrical and Electronics Engineers. Professor **Edward C. Jordan,** head of the Department, was awarded the IEEE education medal, the organization's highest award, and **William J. Fry** and **Jose B. Cruz, Jr.,** have been named fellows in the Institute. Fry is in charge of the Biophysical Research Laboratory; Cruz is leader of the control systems group in the Coordinated Science Laboratory.

Mechanical and Nuclear Engineering Professor **S. L. Soo** delivered the keynote address at the March 4 International Symposium on Two-Phase Flow held at the University of Pennsylvania.

Professor **William J. Hall** is the eighth member of the University of Illinois College of Engineering faculty to receive the highest distinction in his profession; election to the National Academy of Engineering.

He was elected for his contributions to structural engineering, structural mechanics, and soil dynamics. Hall has been a member of the University's Department of Civil Engineering staff since 1949, and is the sixth from that department to be elected to the National Academy.

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 9, NO. 5, MAY 1968

In the order listed, this issue contains articles on the following subjects:

NEW PLANS FOR THE PLATO TEACHING SYSTEM
ILLINOIS' PART IN AN IMPORTANT NEW NATIONAL COMMITTEE
DISINFECTION OF DRINKING WATER
A STUDY TO IMPROVE TEACHING TECHNIQUES

PLATO'S GRADUATION

Tomorrow's education took a big step toward today with the recent announcement of a six-year program to extend the PLATO computer-based education system from the University of Illinois laboratory where it was developed to 4,096 remote PLATO student teaching stations. A $475,000 National Science Foundation two-year grant will finance the first step — demonstration centers in four schools, and continued research to reduce costs and add new features to the system.

The PLATO project, directed by Professor Donald L. Bitzer, is in the Computer-based Education Research Laboratory, a special unit of the University's Graduate College. PLATO — for Programmed Logic for Automatic Teaching Operations — originated at the University in 1960. The system uses a central large electronic computer connected to a television display and teletypewriter keyset for each student.

The first step of the plan calls for demonstration centers, each with at least twelve student consoles, to be set up in the next eight months in Parkland Junior College, Champaign; Washington School, Champaign; Mercy Hospital School of Nursing, Urbana; and the University's School of Life Sciences on the Urbana campus. These will supplement a twenty-station classroom operated in the Laboratory since 1966. They will be controlled by the same electronic computer, and will utilize the computer programs and other developments from the Research Laboratory.

Research will aim at developing an inexpensive prototype teaching terminal in which prestored information on slides can be superimposed on the display which contains the computer-generated information. A random-access audio device to provide the system with a "voice" at the student's station is also being developed.

A major effort toward cutting costs will be based on the revolutionary plasma display panel invented in the University's Coordinated Science Laboratory (see *Outlook,* November, 1967). The panel is a sandwich of thin glass plates on which graphical information can be presented under control of the computer. The panel is a simple structure and potentially inexpensive; it promises further cost-saving because it can be linked to the computer through low-cost telephone lines instead of the high-quality cable or microwave link required by TV's cathode-ray tubes.

The slide projector, also under computer control, will project an image on the display panel to be superimposed on the changeable information presented by the computer. A film plate carrying 256 miniature slides might be purchased like a textbook by a student and inserted into the teaching console.

In case the plasma panel approach is unsuccessful, a back-up program involves redesigning the teaching terminal for economical large-quantity production. This back-up design will utilize the cathode-ray and storage tubes which are now part of the PLATO equipment.

The device to add sound to the PLATO program would involve either equipment located at the central computer or another slide inserted in the teaching station and controlled by the computer.

Two years are set aside for these developments. The program will then move to its final stages, in which a large computer capable of controlling more than 4,000 stations will be ordered and the new stations put into operation.

UNIVERSITY OF ILLINOIS
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A typical student station in the U of I PLATO computerized teaching system provides the student with a visual display and a teletypewriter keyset connected to a large central computer. Recently announced plans for the project, which is directed by Professor D. L. Bitzer, will install 4,096 similar stations in schools by 1974.

The complete installation will proceed through several steps, beginning with testing and evaluation of 32 stations mass-produced from plans developed in the earlier research, then increasing the number to 256, and finally — in 1974 — reaching the goal of 4,096 remote student stations.

The Computer-based Education Research Laboratory was established at Illinois in 1967 to concentrate on the development and use of the PLATO system. It includes specialists not only from engineering, but also from the University's College of Education, Department of Psychology, School of Life Sciences, and other areas. Their goal is an effective, large-scale, computer-based education system in which thousands of students at remote stations will be taught simultaneously — each working independently and at his own speed — at a cost of less than 25 cents per student-hour for use of the student terminal and central computer.

"The PLATO system will produce widespread and radical changes in education and educational technology," Bitzer predicts. "Preparation for these changes requires an orderly and flexible plan of development which includes specialized personnel as well as technology.

"The system should be reliable with proven components, and be capable of modification as warranted by future advances in technology, science, and educational theory. The overall 'system' will include specialists such as teachers, engineers, programmers, lesson writers, and evaluation experts, constituting a large and radically different educational enterprise." ◆

EVERITT HEADS NATIONAL TELECOMMUNICATIONS COMMITTEE

The National Academy of Engineering has announced the formation of a Committee on Telecommunications to conduct a study of developments in communications technology through 1980. The fifteen-member Committee is chaired by William L. Everitt, Dean of the College of Engineering of the University of Illinois. The Committee's members include some of the United States' most respected scientists and engineers, among them Edward C. Jordan, Electrical Engineering Department head at Illinois, and Electrical Engineering and Astronomy Professor George W. Swenson, on leave from the University, who will serve on the Committee's staff.

The Committee will advise both the President's Task Force on Communications Policy, created in August, 1967, to review the nation's domestic and international policies in communications, and the Department of Housing and Urban Development, which is funding the study in connection with its long-range program of research toward improved urban life.

The Committee will first analyze technical and economic data collected by the President's Task Force to determine the extent to which such information provides a basis for policy judgments. It will then prepare descriptions of developments in telecommunications technology that are considered reasonably likely to be available for use by 1980, in order to provide policy makers with a framework of technological options.

The Committee will examine long-distance transmission modes such as satellites, cables, and guided laser beams. It will also consider the problem of distribution of radio, television, telephone, and data signals within cities and the types of terminal equipment that may be available for business and personal use, such as receivers, videophones, and data input consoles.

At the initial meeting of the committee, Everitt said, "We should be able to take a good look into the future of telecommunications, which is dominated by technical development." He said he had confidence that the Committee would "produce a document that will stand as a forward-looking, imaginative blueprint of what communications can be, and what it can do for our society."

Eugene V. Rostow, Chairman of the President's Task Force and Undersecretary of State for Political Affairs, told the members: "The NAE Committee and the Task Force have a rare opportunity to examine the 'ecology of telecommunications.' It is a continuing policy for the United States to maintain the possibility of best use of the available telecommunication technology, especially in order to assist the less developed nations in their efforts toward growth and stability." ◆

INSTANT DRINKING WATER: JUST ADD WATER

The fellow facing a "Water, water everywhere" situation needn't be at sea; he might be living off the land anywhere in the world — a world in which less than 1 per cent of the water from streams and lakes is naturally safe to drink.

To help the thirsty man with an empty canteen, Professor John T. O'Connor is conducting a search for a better method of disinfecting small quantities of drinking water. The method currently used by U.S. Army soldiers involves a tablet called Globaline. While Globaline does an adequate job, it has several shortcomings: its main disinfecting agent is iodine, which gives water a taste, odor, and brown color which many people find objectionable. While these characteristics provide sure indicators of the presence of the iodine, they aren't very appetizing.

Another of the drawbacks of the Globaline pill is that its effectiveness can vary. Its iodine may spend itself on reactions with organic material in the water before it gets to the actual job of disinfecting. The tablet requires several minutes to dissolve, and an additional 20-30 minutes to complete its disinfection. The tablet's packaging renders it vulnerable to loss of potency, and exposure to heat or humidity may make it hard to dissolve.

O'Connor is working on an improved pill which might use chlorine for a disinfectant instead of iodine, thus eliminating iodine's objectionable color, taste, and odor. Ingredients such as sodium bicarbonate and citric acid could decrease the alkalinity of the water and improve the effectiveness of the chlorine, give the water a pleasant taste, and make the pill effervescent to speed its dissolution and disinfection time. Packaging individual doses would help keep the pills effective.

Professor O'Connor is assembling information on chemicals such as organic chlorine or iodine complexes which might perform better at disinfecting small quantities of drinking water. If his laboratory work succeeds, its final test will be made beside a stream somewhere, by someone with the credentials that qualify him as an expert: he's thirsty. ◆

CAN MAGNETOHYDRODYNAMICS BE BOX OFFICE?

Some of the liveliest, most inspiring — and some of the most sporific — performances ever given are given by teachers in their classrooms. Good teaching involves both art and science, and certainly at least the science can be studied, worked on, and improved. But the teacher trying to improve his technique has always faced one problem: he can't see himself at work.

Video-taping equipment records the interaction between General Engineering Professor Robert Jewett and his students in an Engineering History class. The portable, inexpensive equipment, which can be used in almost any classroom, is part of a study being conducted by Arye Perlberg, Professor of General Engineering and of Vocational and Technical Education.

Teachers at the University of Illinois, however, are doing just that. As part of a study directed by Arye Perlberg, a visiting Professor of General Engineering and of Vocational and Technical Education, audio-video tape recordings of classroom situations are providing teachers with a valuable glimpse of themselves. While video tapes aren't new, portable equipment for making and playing them is. The new, smaller, less expensive equipment permits recordings to be made with minimum disturbance in the classroom and provides quick and repeated reviews of the teacher's interaction with his students.

Because the tapes can be played repeatedly, the teacher (and perhaps his colleagues or a consulting expert) can make a detailed, thoughtful analysis of his pedagogical style. In some cases, split-screen recordings may be used to show the instructor and his students simultaneously, so that he can observe their immediate reactions.

The video-tape review has also been applied to "microteaching," in which it records a short teaching session of five to twenty minutes and repeats it immediately. After studying a few key points of his technique, the teacher can return to the classroom to teach the same material again, this time trying to improve his method.

The video-tape techniques have been used in engineering and other classes at Illinois, and the results have been encouraging. For the first time, the instructor sees himself as others see him — a potentially disquieting experience, and an enlightening one. ◆

HEADLIGHT GLARE STUDY AVAILABLE

Engineering Experiment Station Bulletin 496, *An Investigation of Headlight Glare as Related to Lateral Separation of Vehicles,* by L. A. Webster and F. R. Yeatman, is available from the Engineering Publications Office for $3.00. Descriptions of and results from several kinds of tests for disability and discomfort glare are discussed. The study should be useful for traffic engineers and others concerned with highway design. ◆

PEOPLE AND PLACES

A tie by two engineers in the second annual graduate student paper competition sponsored by the University of Illinois Chapter of the Society of Sigma Xi has been announced by Professor Helmut H. Korst, president of the Society.

Henry J. Petroski in theoretical and applied mechanics, and **Genn Saji** in nuclear engineering, tied for second place and were awarded $75 each. Petroski and Saji are doctoral degree candidates in the University. Their prize papers, which have been published, were selected from 24 papers by a panel of nine judges from as many different scientific disciplines. Professor Franz E. Hohn, chairman of the judges, described the winners as "absolutely superb papers of professional quality" and said that any professor would be proud to be the author of any of them.

Petroski's paper was published in the German *Zeitschrift für Angewandte Mathematik und Physik* (Journal for Applied Mathematics and Physics). It is titled "Controllable States of Rigid Heat Conductors," and presented a new mathematical analysis, which the judges said gave "astonishing results which should be verifiable experimentally." Saji's paper was published in *Nuclear Science and Engineering.* It is a new theoretical contribution which has been verified experimentally by independent researchers and will be important in reactor design. The title is "Excitation of Higher Space Moments in Reactor Transfer Function Measurements."

Chairman Glenn T. Seaborg of the Atomic Energy Commission has announced the appointment of Civil Engineering Professor **Chester P. Siess** of the University of Illinois to the Commission's Advisory Committee on Reactor Safeguards. The ACRS is a statutory committee established to advise the Commission on the safety aspects of proposed and existing nuclear facilities and the adequacy of proposed reactor safety standards.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 9, NO. 6, JUNE 1968

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In the order listed, this issue contains articles on the following subjects:

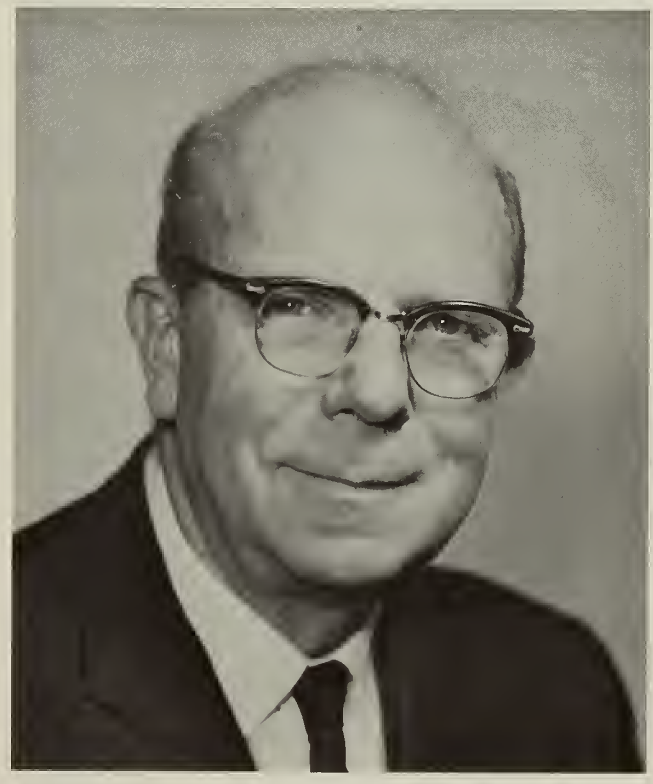
RETIREMENT OF ENGINEERING DEAN EVERITT
AIR-POLLUTION RESEARCH
A NEW SYSTEM FOR MONITORING TRAFFIC
A STUDY OF HIGHWAY MEDIAN WIDTHS AND HEADLIGHT GLARE

EVERITT, DEAN OF ENGINEERING AT ILLINOIS, RETIRES

On April 18, a retirement dinner called "The Ineverittable Conclusion" was held at the University of Illinois for William L. Everitt, Dean of the College of Engineering since 1949. The occasion illustrated both Dean Everitt's well-known sense of humor and the affection his friends and colleagues have for him, because it was surely one of the zaniest evenings in the University's century-old history.

In a slide presentation entitled "The Unforgettable Man: W. L. Whatshisname," he was facetiously linked with nearly every engineering disaster in history. He was given a sailboat with the salty advice that "you have to go far from here to find a good place to sail." He was also presented the first annual W. L. Everitt Teaching Excellence Award by the engineering students, who ended a summary of his contributions to engineering education with thanks for "staying away from the classroom for the last few years." The students said of the award, which was a bust of Everitt himself, that they were disappointed with its appearance, "but it has occurred to us that that is more your fault than ours." Everyone enjoyed the evening's pranks, but no one enjoyed or added more to their liveliness than the Dean and the members of his family.

Dean Everitt has achieved eminence for his work in industry, government, private consulting, and higher education. He has served on countless government and military panels and committees. He has been President of the Associated Midwest Universities, the Institute of Radio Engineers, the American Society for Engineering Education, and the Engineers' Council for Professional Development. He has held high positions with the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the Engineering College Administrative Council, and the Commission on Engineering Education. He has written numerous books and articles and has been the editor of a series of electrical engineering texts for many years. He was a founding member of the National Academy of Engineering, and was recently elected to the ASEE Hall of Fame. For his many achievements in engineering and in higher education he has received countless medals and awards, and has been given eight honorary degrees.



The College of Engineering achieved world-renowned eminence during Dr. Everitt's tenure as dean. But despite the energy and time required for this job and his many outside activities, he was always willing to talk to students and to help them with their problems. When his retirement was announced, the student magazine described his achievements, but pointed out that it honored him for something that might, by comparison, sound trivial: "He has listened to and respected the opinions of the students of his own college." It was obviously not a trivial commendation to the students who gave it.

Dean Everitt will retire in November, when he will be succeeded by Daniel C. Drucker of Brown University, Providence, Rhode Island. Professor Drucker has been the chairman of the Division of Engineering and of the Physical Science Council at Brown, where he is presently L. Herbert Ballou University Professor.

Dean Everitt leaves the University with a very full career behind him, and an equally full one ahead of him. He will continue to work with various governmental groups, to serve on committees dealing with the problems of higher education, to consult for industrial companies, and to edit and write technical articles and books. He has recently been appointed editorial chairman of the magazine *Electro-Technology,* for which he will edit and write articles about new developments in electronics in this country and abroad.

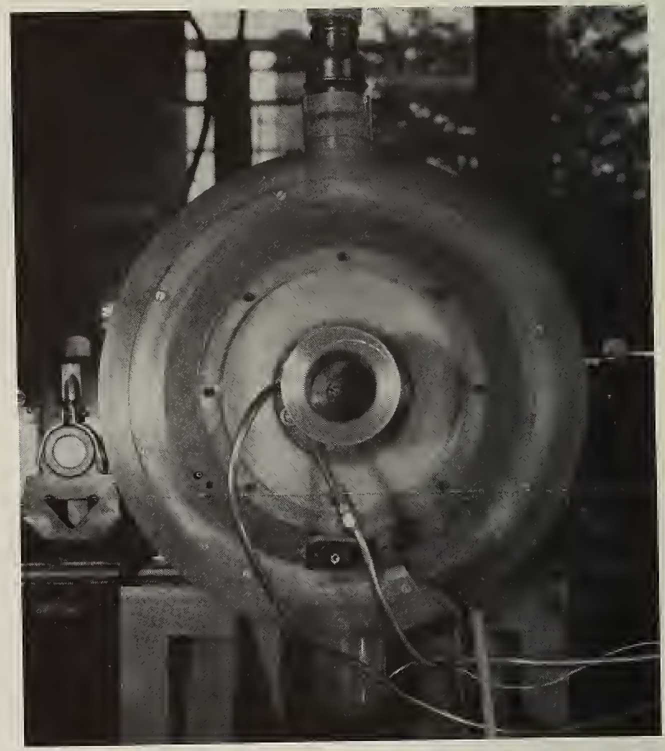
Perhaps the most notable evidence of his splendid reputation is his recent appointment as Chairman of the National Academy of Engineering's Committee on Telecommunications. In this capacity he will work with fifteen other eminent engineers in producing, for the President's Task Force on Communications Policy and the U.S. Department of Housing and Urban Development, a blueprint for what communications can and should be by 1980.

He will continue to reside in the Champaign-Urbana community during what seems inappropriately called his "retirement." ◆

BREATHTAKING IT AIN'T

Smoke, as the song says, gets in your eyes. What the song neglects to say is that smoke also gets in your nose, mouth, throat, and lungs, and what it does there can be pretty nasty. But perhaps these aren't the lyrics for a romantic ballad.

They are good reasons for public concern and action, and at the University of Illinois they're the reasons behind some worthwhile research into controlling air pollution. Since 1964, Professor S. L. Soo of the departments of Mechanical and Nuclear Engineering has directed work which has two aims: to develop instruments which can continuously indicate the smokiness of gas in a smokestack or elsewhere, as a necessary first step in preparing and enforcing air-pollution legislation, and to find cheaper, more effective ways to trap dust and smoke before they escape into the atmosphere.



Making smokestacks less smoky is the job of this electro-aerodynamic precipitator, invented by University of Illinois Professor S. L. Soo of the departments of Mechanical Engineering and Nuclear Engineering. In this test model, particle-laden gases enter at the top, are swept clean by high-voltage static electricity (the electrical lead is at lower right), and the clean gas emerges from the tube in the center. The smoke particles, mixed with a small amount of water, drain from the outlet at the bottom of the apparatus.

The electrostatic precipitator, introduced in 1910, has provided a relatively effective way of using high-voltage electricity to clear dust and smoke particles from a gas, and a definitive study of its operating principles has been made in U of I laboratories. But the electrostatic precipitator has had one built-in drawback: its system of plates and wires, used to apply an electric charge to the smoke particles, generates an "electric wind" which sweeps some of those particles back into the flow stream, and thus out the smokestack and into the atmosphere.

Electro-aerodynamic flow research under Professor Soo uncovered this problem, and related work has produced a solution. A University of Illinois Foundation patent is pending on his invention of an improved electro-aerodynamic precipitator which avoids the problems previously associated with electric winds by aligning them in the direction of gas flow, so that they do not interfere with the collection of particles. Preliminary tests show dust removal efficiencies as high as 99 per cent for the new precipitator, and further development may improve this figure. Perhaps the machine's greatest advantage over conventional systems is its compactness: it can be one-tenth to one-twentieth their size, and still do a comparable job.

A less social but nonetheless practical benefit that the new machine shares with its predecessors is that the material they recover from smokestacks is sometimes valuable enough to help repay some of the expense of collection. Perhaps reasons such as this, reduced costs for anti-pollution devices, and meaningful, enforceable legislation will prevent the possibility of lethal air from becoming a reality. We'll breathe easier when it does. ◆

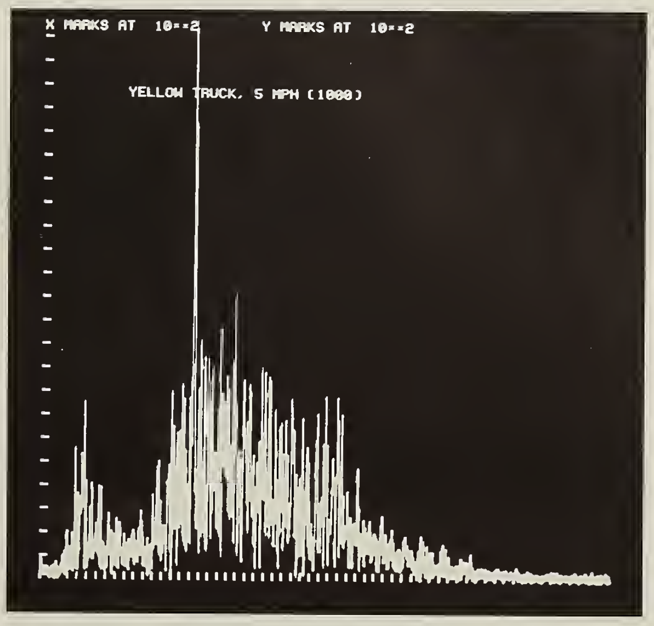
RUMBLEPRINTS

Any Indian scout, political candidate, or management trainee knows that it's important to keep an ear to the ground. University of Illinois researchers in the Coordinated Science Laboratory know it too; in fact, they're putting "ears" *in* the ground as part of an unusual new system for keeping tabs on traffic.

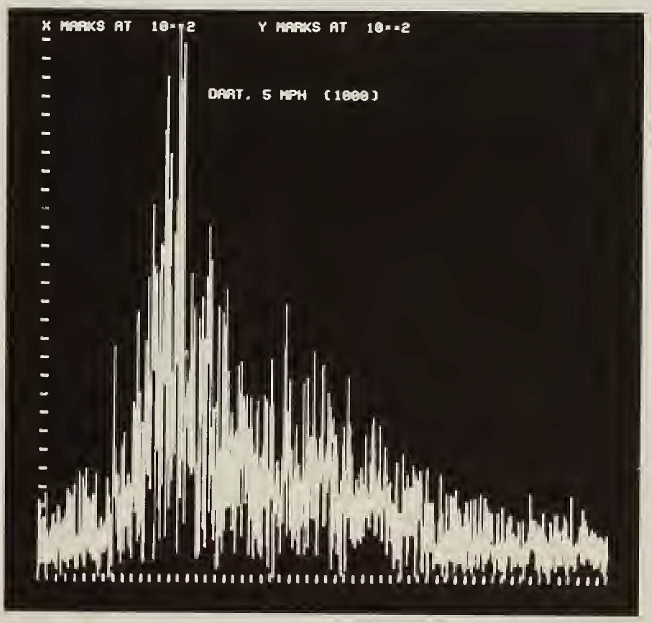
Professor H. W. Knoebel and Senior Research Engineer B. D. Kirkwood are investigating the use of underground vibrations for traffic detection. Their equipment consists of a digital computer and specialized microphones called geophones buried a few feet underground. The geophones detect vibrations from nearby traffic of any kind, whether human, animal, or vehicular, and pass these seismic signals along as tape recordings for processing and analysis by the computer. As its output, the computer displays the discrete frequencies present in the received signals.

Knoebel and Kirkwood soon found that noises from wind and walking men or animals had very little regularity, and that the computer analysis could easily distinguish between these signals and those from vehicles. Another discovery was even more promising: each of the test vehicles had its own vibratory "signature," a characteristic set of relative frequencies by which it could be identified. Would it be possible to use the peculiarities of each model of car or truck — the frequencies of vibration of key elements such as engine, drive shaft, and wheels — as a way to identify it automatically?

Not without a bit more work, the researchers discovered. As the vehicles traveled faster or slower, the frequencies of their entire signatures rose and fell. Like the sound of a whistle on a passing train, the vibrations changed depending on whether the vehicles were approaching or leaving the geophones.



A buried microphone detects vibrations from a passing truck (top) and car (bottom). Differing vehicle "signatures" such as these are helping researchers at the University of Illinois develop a system which detects vehicles by their underground vibrations. The research is conducted by Coordinated Science Laboratory Professor H. W. Knoebel and Senior Research Engineer B. D. Kirkwood.



This doppler shift in frequency and the frequency changes due to different speeds could be overcome by having the computer base its analysis of a vehicle's signature on the lowest frequency in that signature, and then measure the remaining frequencies relative to that base. Then the computer could produce a clear picture of a vibratory signature regardless of changes in its overall frequency.

Future research may lead in two different directions. The first would be the development of a self-contained system which would not require the use of an external computer. This kind of detection unit would have a variety of uses — the army might plant these automatic "listening posts," for example, to monitor the movements of military traffic in areas frequented by civilian vehicles as well.

The second possible application would be a system which would monitor traffic for number and speed of vehicles. This system might function as a traffic control center for regulating traffic signals and speed limits in response to varying traffic conditions. It might lead to some surprises in law enforcement as well: a trooper's first remark to a dismayed motorist might be, "I heard you speeding." ◆

HAPPY MEDIAN

Between election years, the middle of the road is a pretty neglected place. Lately, though, the middle of the road — the highway median strip — has received attention from University of Illinois civil engineers studying the relationship between automobile headlight glare and the lateral distance of car separation.

In a recent study, Project Supervisor R. H. Wortman and Project Investigator L. A. Webster led work to find the effects of headlight glare upon the driver. On an unopened section of interstate highway, they measured effects of varying median separation on two types of headlight glare: disability glare, which causes a measurable decrease in a driver's vision, and discomfort glare, which has no physiological effect, but is annoying and can impair driving efficiency.

Disability glare tests involved four different median widths and two types of visibility targets. Automobile tail light reflector assemblies and felt-covered wooden markers were used to represent a variety of more or less conspicuous road hazards, and variables such as the ages of test drivers and high- or low-beam illumination were considered. The test results varied under these different conditions, but they showed that a 33-foot median width is adequate to protect the vision of a driver traveling with high-beam headlights at 70 mph.

The project staff used similar glare sources for their discomfort glare tests, which involved both moving and static vehicle test conditions. Again the results varied with different drivers and conditions, but the researchers were able to conclude that a 94-foot lateral separation between oncoming cars would eliminate discomfort glare.

A broad program of research relates to highway design at Illinois. From these studies in a variety of related areas, the process of building better, safer highways can be made less dependent upon opinion and guesswork, and more literally a matter of fact. ◆

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AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 2, OCTOBER 1968

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In the order listed, this issue contains articles on the following subjects:

COMPUTER-AIDED AEROSPACE SYNTHESIS
A RAINFALL SIMULATOR
A SURVEY OF GRADUATING ENGINEERS
LECTURE SERIES ON MAN'S ENVIRONMENT

WELL, BACK TO THE OLD COMPUTER

The University of Illinois – designed space capsule had reached 125,000 feet when it began to break up. Shortly afterward, an Illinois-designed aircraft had just cleared the ground when its left wing began to crumple and fold. These two separate events were punctuated by the anguished cries, not of passengers, but of student aerospace engineers. Both "tragedies" were only simulated by a new computer program developed to eliminate much of the time-consuming calculations which have hindered aerospace synthesis courses in the past.

The success of this effort to simulate vehicle flight characteristics by computer resulted from a desire to improve aeronautical engineering courses at the University of Colorado and the University of Illinois. The study, sponsored by the two universities' cooperative BUILD program, was conducted by a team of graduate students and faculty members headed by Aeronautical and Astronautical Engineering Professor Harry H. Hilton. The University of Colorado's consultant was K. D. Wood.

In the past, the student, overwhelmed by staggering amounts of calculation, often lost sight of his objectives in a maze of computer programming drudgery. To avoid this difficulty, he was forced to work with only part of the entire design, confining himself to flight structures, power plants, or flight analysis. The new program, which resulted not only from the innovations of the study group, but also from the use of material supplied by industrial sources and NASA, will allow the student engineer to choose the type of vehicle he wishes to design by specifying the weight, size, and mission requirements.

The design portions of the program can determine the structure, size, and weight of straight and swept wings; describe the best fuselage shape; and calculate the effects of building the vehicle with different materials. The evaluation sections of the program will "fly" the newly designed vehicle through a simulated mission. One subprogram can launch, track, and recover a space vehicle. Another can fly a plane from takeoff to landing through a mission of any complexity, while providing a continuous in-flight record of speed, weights, and stresses.

Although the program is extremely versatile, Professor Hilton emphasized the fact that it is only a tool: it lets the engineer develop and evaluate a flight vehicle in a short time. Its real advantage in an educational program is the "feel" for aerospace design which it gives the student engineer. The fact that the new program relieves him of time-consuming programming is important, but its most attractive feature is that it does not make the major decisions for him — he learns by making these decisions himself.

With the increasing size and capabilities of modern computers, it is possible that design and fabrication might eventually take place completely without human intervention. Until then, the student engineers and the computer will have to help each other over the rough spots. ◆

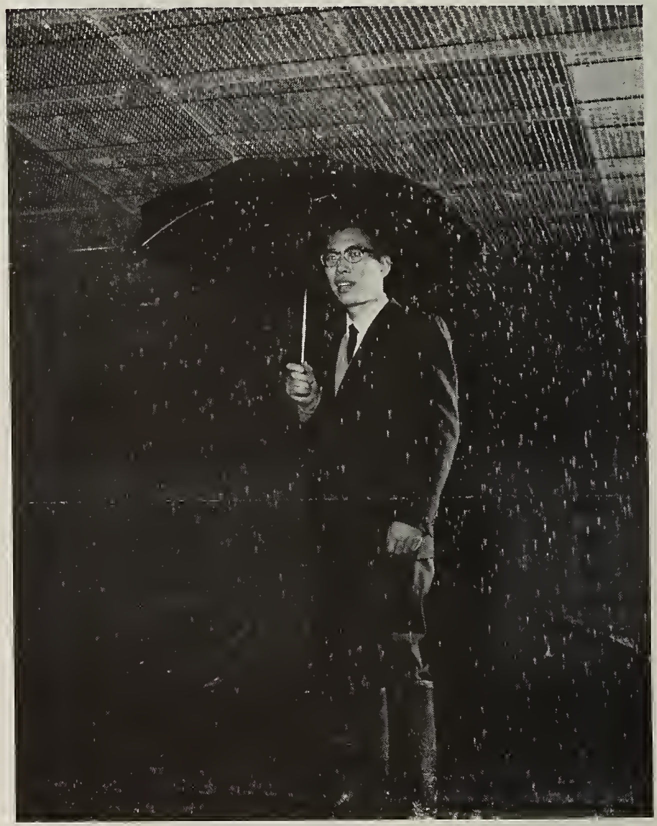
WEATHER OR NOT

Like the sorcerer's apprentice, Hydraulic Engineering Professor Ven Te Chow can't control the thunder and lightning, but he *can* control the rainfall — at least over 1600 square feet of the Hydraulic Engineering Laboratory at the University of Illinois. Data from Professor Chow's Watershed Experimentation System (WES) will help hydrologists predict and control runoff due to rainfall.

One hundred computer-controlled valve assemblies regulate the rainfall over a 40- x 40-foot basin. Each valve assembly can be independently controlled to produce anything from an intermittent spring shower to a monsoon cloud burst moving over the landscape just as a rainstorm moves in nature. Since no two rainstorms have ever been exactly alike — until now — factors affecting runoff vary considerably. The WES storm is stored on punched computer tape so it can be "replayed" any number of times, providing researchers with a fixed set of conditions under which the runoff may be investigated. The shower's identical raindrops are produced by a maze of polyethylene tubing; when the entire system is in operation, almost a quarter of a million drops can be made at once.

The polyethylene and plexiglass ceiling is constructed above a runoff basin built on wooden platforms which can be adjusted to form a watershed of any desired shape. During the simulated rainstorm, the runoff from the basin is collected and measured electronically in a concrete outflow tank. By varying storm conditions and the terrain features of the basin Chow hopes to learn the mechanics of surface water flow. A better understanding of surface runoff will help solve problems of flood control, bridge and culvert design, and irrigation in arid areas.

Future plans for the WES include modifying the runoff basin to provide more realistic terrain features; plastic "mountains," sponge "fields," and wire and mesh "trees" and "grass." These improvements and increased interest in watershed hydraulics will keep the WES busy working up a storm. ◆



Hydraulic Engineering Professor Ven Te Chow enjoys a shower under the world's largest rainfall simulator. By measuring the rainfall runoff from model watersheds, University of Illinois hydrologists hope to determine the natural laws governing surface water flow.

MONEY TO WASTE

The United States Public Health Service has announced that it will provide $240,000 in support of a new interdepartmental program to train students in techniques of managing the huge quantities of solid wastes generated by municipal, industrial, and agricultural activities. This program will be offered by the departments of Civil Engineering, Agricultural Engineering, and Food Science. The five-year program, directed by Professor Richard S. Engelbrecht, will have five M.S. candidates initially, but will eventually be expanded to support eight of them. ◆

INDUSTRIAL GRANTS SUPPORT COORDINATED SCIENCE LABORATORY

Two unrestricted industrial grants of $25,000 each have been established by the Ford Motor Company and Owens-Illinois to support research in the Coordinated Science Laboratory. Although use of the funds is unrestricted, each firm indicated interest in an area of the laboratory's research. Owens-Illinois is interested in display devices and thin-film effects; Ford, in transportation and regional growth modeling and associated computer graphics techniques. ◆

THAR'S GOLD IN THEM THAR HILLS

In 1851, a midwestern newspaperman (not Horace Greeley!) offered the sage advice, "Go West, young man." Nearly 120 years later, many University of Illinois engineering graduates are heeding this advice. According to a survey released by the Placement Office of the College of Engineering, almost one-quarter of the working June B.S. recipients in engineering have accepted positions west of the Rockies. Most of them won't have to find their fortunes the hard way: their average monthly starting salary was a record high of $780.

The wild west did not capture a majority of the class. Even more of them, nearly 30 per cent, chose to work in Illinois, with the Chicago area getting the lion's share, 21 per cent. The graduates also showed a very practical interest in continuing their educations: 20 per cent of the class is going directly to graduate school. Graduates going to work frequently cited company-sponsored educational programs as a major factor in the selection of an employer.

The largest number of graduates continue to be employed by aerospace (20 per cent), electronics (12 per cent), and electrical equipment (11 per cent) industries. The federal government (8 per cent) has moved from ninth to fourth position as an employer of U of I engineering graduates. And, the employers are paying their graduates well: average monthly starting salaries are up 8 per cent from a year ago, and over $200 a month from ten years ago.

Engineers no longer have to go west to strike it rich — thar's also gold in the flat country. ◆

NEW ADDITIONS TO TECHNICAL REPORT SERIES

Construction Research Series No. 11, "Automated Reproduction of CPM Networks," by M. B. Buckley and L. R. Shaffer is available from the Engineering Publications Office at a price of $3.00. The Construction Research Series has been widely used by construction companies and other contractors to assist in their scheduling. The latest report in this series outlines the use of the CPM method to assist the contractor in planning a project as well as in scheduling it. ◆

CIVIL ENGINEERS SURVEY THEIR SURROUNDINGS

A fund established by the Civil Engineering Alumni Association during the centennial celebration of the University of Illinois has made possible the presentation of a series of seven public lectures on "Our Environment — The Civil Engineer's Challenge."

The keynote address, given on October 8 by Rolf Eliassen, Professor of Civil Engineering at Stanford University, examined the role of the civil engineer in improving the environment. The six remaining lectures will take place in November and December, 1968, and February, March, April, and May, 1969. Topics to be covered include Construction, Transportation, Water Usage, Pollution, and Design of High-Rise Structures. The final address will explore the interdisciplinary relationship between engineers and other professionals who shape the aesthetics of our environment.

Inquiries about the lectures should be directed to Professor Richard I. Dick, 3230 Civil Engineering Building, University of Illinois, Urbana, Illinois 61801. ◆

ORDER FORM FOR NEW PUBLICATIONS

☐ Bulletin 494, *Stress Concentration at External Notches in Members Subjected to Axial Loadings,* by A. T. Derecho and W. H. Munse. *$3.00.*

☐ Bulletin 495, *Model Studies of the Dynamic Response of a Multigirder Highway Bridge,* by W. H. Walker. *$4.00.*

☐ Bulletin 496, *An Investigation of Headlight Glare as Related to Lateral Separation of Vehicles,* by L. A. Webster and F. R. Yeatman. *$3.00.*

Four of the reports in the popular Hydraulic Engineering Series have been reprinted and are again available:

☐ HES 2, *Hydrologic Studies of Urban Watersheds: Rainfall and Runoff of Boneyard Creek Watershed, Champaign-Urbana, Illinois,* by V. T. Chow. *$2.25.*

☐ HES 3, *Desilting Structures for Highway Drainage Systems,* by J. C. Gillou and V. T. Chow. *$2.25.*

☐ HES 4, *Hydraulic Studies of a Highway Bridge,* by I. J. Hickenlooper, J. C. Gillou, and V. T. Chow. *$3.00.*

☐ HES 6, *A Study of Distribution System Equalizing Storage Hydraulics,* by M. B. McPherson. *$3.25.*

☐ The entire series of four reports may be purchased for $9.50.

The Construction Research Series has been continued with the following new publication:

☐ CRS 11, *Automated Reproduction of CPM Networks,* by M. B. Buckley and L. R. Shaffer, *$3.00.*

Other publications:

☐ Proceedings of the Tenth Sanitary Engineering Conference, *Waste Disposal from Water and Wastewater Treatment Processes. $4.00.*

☐ Catalog, *A listing of Engineering Publications, 1904-1967. No charge.*

☐ *A Summary of Engineering Research, 1967. No charge.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

☐ *Men and Ideas in Engineering,* hard bound, 58 photographs, 10 diagrams, 164 pages. *$5.00.**

Send with remittance to Engineering Publications, 112 Engineering Hall, Urbana, Illinois 61801.

*Illinois residents please add 5% sales tax.

PEOPLE AND PLACES

The Water Pollution Control Federation has announced that Director **Ben B. Ewing** of the Water Resources Center and Sanitary Engineering Professor **Richard I. Dick** have been awarded the Harrison Prescott Eddy Award for their technical research paper, "Rheology of Activated Sludge." They received their award at the forty-first annual conference of the Federation.

Professors **Roger R. Yoerger** and **James O. Curtis** of the Department of Agricultural Engineering have won two of seven awards presented by the American Society of Agricultural Engineers at the society's sixty-first annual meeting. Yoerger's paper, "Bridging the Gap with a General Purpose Analog," and Curtis' paper, "Stresses in Plywood Gusset Plates for Trusses," were selected from nearly 300 entries.

Professor **Ellis Danner** of the Department of Civil Engineering has been recommissioned in the National Defense Executive Reserve in which he has served since 1960. Recommissioning followed the shift of the Bureau of Public Roads from the Department of Commerce to the new Department of Transportation. The Reserve is composed of knowledgeable people, not currently in the federal government, who can step into key posts in the event of an emergency.

Six members of the College of Engineering faculty are included in the first edition of *Who's Who in Medical Engineering,* published by the International Institute for Medical Electronics and Biological Engineering. Listed are Electrical Engineering professors **H. W. Ades, M. L. Babcock, Floyd Dunn,** and **H. C. Roberts.** Also included are **W. J. Fry,** the late head of the Biophysics Research Laboratory, and **Heinz Von Foerster,** Professor of Electrical Engineering and Biophysics.

Professor **Nathan M. Newmark,** head of the Department of Civil Engineering, is one of 12 academic and industrial experts named by the President of the National Academy of Sciences to its new Computer Science and Engineering Board. The Board will assess implications of the growth of information processing technology as it affects public and private sectors of the nation.

Hydraulic Engineering Professor **Ven Te Chow,** of the Department of Civil Engineering, has been named Consulting Advisor to the United Nations on the world's water resources problems. He will assist the U.N. Secretariat and various panels of experts in answering technical, economic, and other questions relating to specific water problems. ◆

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 3, NOVEMBER 1968

In the order listed, this issue contains articles on the following subjects:

THE NEW DEAN OF ENGINEERING
AN EDUCATIONAL SYSTEM FOR THE SIGHTLESS
A PROGRAM TO TRAIN ENGINEERING EDUCATORS
ILLINOIS SUPPORT FOR AFRICAN ROAD CONSTRUCTION

D. C. DRUCKER BECOMES DEAN

"Tall, quiet, soft-spoken" are adjectives that occur to a person first meeting the new Dean of Engineering at Illinois. He has also been described as "extraordinarily productive in research" and "outstanding in educational and professional leadership." As of the middle of this month he began to think of himself as "a man with a very tough job at the University of Illinois."

Daniel C. Drucker came to Illinois from Brown University, where he was a professor of engineering and L. Herbert Ballou University Professor. He succeeded Dean William L. Everitt, who retired after 24 years with the University, 19 years as Dean of Engineering, and nearly 50 years of outstanding service to his profession.

Drucker was born in New York City in 1918, earned bachelor's, civil engineer, and doctor's degrees from Columbia University. He is a registered professional engineer in Rhode Island. He taught at Cornell University from 1940–43 and at the Illinois Institute of Technology from 1943–45. He was with Armour Research Foundation from 1946–47.

His experience, in addition to teaching and research, has included work in the field office for construction of the Queens-Midtown Tunnel in New York and two years as full-time supervisor of industrial research on mechanics of solids at Armour Research Foundation in Chicago. In 1966 he received the von Kármán Medal of the American Society of Civil Engineers for contributions to mechanics of solids and engineering structures.

He is technical editor of the *Journal of Applied Mechanics* and on the editorial board of *Quarterly of Applied Mechanics;* author of a textbook, *Introduction to Mechanics of Deformable Solids,* and of portions of other technical books. He has published more than 90 papers in technical journals.

Drucker is chairman of the U.S. National Committee of Theoretical and Applied Mechanics and a U.S. delegate to the General Assembly of the International Union of Theoretical and Applied Mechanics, past president of the Society for Experimental Stress Analysis, and past chairman of the Applied Mechanics Division of the American Society of Mechanical Engineers.

He is a fellow of the American Academy of Arts and Sciences, American Society of Civil Engineers, American Society of Mechanical Engineers, and American Association for Advancement of Science, and an associate fellow of American Institute of Aeronautics and Astronautics. In 1967 he was elected to the National Academy of Engineering. ◆

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TO AID THE SIGHTLESS, A MACHINE LEARNS TO TALK

A recently completed course of study on the Illinois campus gave credibility to the engineering slogans that end with the words "for the benefit of mankind," although it was specifically for the benefit of individuals — blind ones. A class of eighteen students, representing sociology and psychology as well as engineering, were participants in the year-long program. The study, offered as an engineering honors course, challenged the class to examine the problems of the blind, and then design some beneficial system or device for them. The students faced the problem of producing a system that was technically correct, socially workable, and psychologically acceptable to the sightless.

The class began by inviting experts in the fields of biophysics, psychology, and biochemistry to give them background in the problems of the blind. They also worked with staff members and blind students from the Student Rehabilitation Center. After coming to understand the seriousness of the educational problems of a person who cannot see, the class chose to design an instructional system for blind students. The class recognized the potential of the University of Illinois' computerized PLATO teaching system as a basis for their project.

To adapt the PLATO system, two major shortcomings had to be considered. The PLATO system requires the student to read messages from a television screen and type replies on a typewriter-like keyboard. The blind student could not read the output on the television screen, and he could not operate the keyboard which provided input for the computer.

The obvious answer to the output problem was to make it audible instead of visible, but the way to do so was not so obvious. The computer would have to call and produce any word or phrase of instruction in random sequence without a noticeable delay between words; this could not be done with magnetic tape. The class decided to convert 128 audible words into digital information, storing this on a random access disk storage unit. The entire contents of the disk could be scanned in 180 milliseconds, and the digital information reconverted to audio with no noticeable delay between words. The class then designed an analog-digital converter that could translate the audio words into digital information. It could be built for under $100 — inexpensive enough so that one could be provided for each student station in the PLATO system.

The input problem required a different sort of solution. Although the class discovered that most blind students have learned to type on a standard keyboard during grammar school, the keyboard used by PLATO was more complicated. Some other method of getting the student in contact with the computer was needed. Nearly all blind students are familiar with the Perkins Brailler, a simple six-key device for writing Braille. An existing model of the Brailler had been modified to communicate directly with PLATO, and the students installed this device to solve their problem. After learning the computer language, the students arrived at a method that gave the blind students adequate control with the Braille keyset.

Now the class faced a problem of an entirely different kind — the problems of a human being. Blind persons are limited in their learning abilities not only by their lack of eyesight, but also because many of them face other problems such as lack of spacial concepts. Many have difficulty with mathematics since they have to do most of the computations mentally. The class was faced with finding lesson material that was suitable not only for use on the computer, but also suitable for blind students. They decided to write a lesson plan on the use of the abacus. The abacus can be used to perform the four major operations of arithmetic and is easily used by the blind.

Each blind student was given some audible information by PLATO on the operation of the abacus. If he did not understand or hear the information, he could press keys that would cause the message to be repeated. He was then asked to perform an operation on the abacus and give the computer his answer. If the answer was correct, the student could be given another question or more information. If it was incorrect, he would be given a "help sequence" that would further explain the material and give the correct answer or ask another question.

To test the value of the system, the class devised a pretest and a post-test on the use of the abacus, both of equal difficulty. Scores on the post-test were considerably higher, indicating that the lessons were successful.

The students felt that the study met their goals with varying degrees of success. Some felt that working with the blind was not a suitable subject for systems engineering since it is difficult to define inputs and outputs of a system that is nonmathematical in nature. But even so, they had solved their first problem in working with the most complex of all unknown quantities — man. ◆

. . . AND COMES IN A PLAIN BROWN WRAPPER

Has your wife (husband, son, daughter) yet read our slightly (but not overly) provincial, fairly (but not bewilderingly) popular book, *Men and Ideas in Engineering*? Many people have, especially since the Engineers' Council for Professional Development has been recommending it in 32,000 high schools across the United States, and since the April 6, 1968, issue of *Saturday Review* reprinted one of its stories. But while modesty prevents further discussion of the book's successes (and its many favorable reviews), an early infusion of holiday spirit raises the question: Wouldn't someone you know like a copy as a Christmas gift? Five dollars at better bookstores everywhere — or from better engineering publications offices, such as the one at 112 Engineering Hall, University of Illinois, Urbana 61801. ◆

A PROGRAM TO ENGINEER TEACHERS

The University of Illinois has had outstanding success in a special program to train engineering teachers. The program, established by the Ford Foundation in 1960, has provided nearly a half-million dollars toward the establishment of a Forgivable-Loan Fund which encouraged graduate students to complete their Ph.D. with an eye toward becoming engineering educators.

The final report of the program showed that the fund had assisted 114 men in obtaining master's degrees. Ninety-three of them went on to complete doctoral degrees, and another 15 are presently working toward doctorates which will be completed in a year to 18 months. Of the 93 Ph.D.'s, over 75 per cent have become associated with educational institutions, and a high ratio of the remaining 15 will do so. Several of those who went on to research have been teaching night school.

"The demand for engineering teachers remains strong," the report indicated, "but the extraordinary demand of three years ago was greatly alleviated by the extra surge of available men provided by the Forgivable-Loan Program backed by the Ford Foundation." The loans are forgiven for those going into engineering teaching for five years or more, while those who do not become teachers must repay the loans. The engineering doctoral graduates from the U of I are now located in schools all over the United States and Canada. ◆

SOIL STUDIES IN SIMBA COUNTRY

Illinois engineers laying out roads rarely have worries about the possibility that lions may be crawling through the nearby bushes. Such a possibility was less remote than usual recently, when a team of U of I civil engineers and geologists under the leadership of Professor R. B. Peck spent a week in Kumasi, Ghana, as consultants to the Agency for International Development. The team was seeking methods of using the native soil in road and highway construction.

Good roads are essential to a nation's development. They bring the entire country closer to its centers of industry and allow a rapid development of natural resources. But, if native materials cannot be used, the cost of road construction can often cripple a nation's efforts to establish a highway system.

Africa does not have the same type of soil which covers much of the United States and Europe; large areas of the continent are blanketed with lateritic soils and gravels. Millions of years of hot, humid African climate have weathered the soils, dissolving the bases and silica, leaving behind a reddish soil high in aluminum and iron hydroxides. The typical highway in the United States is built on dark-colored soil by laying a bed of gravel or sand, binding it with concrete or asphalt, and paving over these layers. The problem is that no one seems to know if this approach will work using the reddish lateritic soils and gravel which are native to the region. The consulting team will help find out how these materials will hold up in road construction and how well they can withstand the wind, rain, and sun of the erosive African climate.

While research is carried on through the government of Ghana, results will be applied to large portions of Africa where the lateritic soils are present. With the completion of the project, the road to an emerging African economy will not only be quicker, it will have fewer potholes. ◆

A model shows the proposed installation of ILLIAC IV. Its four quadrants house 256 processing units, each of which solves a portion of a single large problem simultaneously. Each processing unit uses arrays of advanced integrated circuits and high-speed thin film memories. ILLIAC IV will execute one billion instructions per second. It will be used by the University of Illinois for worldwide weather forecasting, seismic applications, simulation of the human brain, and other advanced applications. It will occupy an area of 40 feet by 120 feet and will be 7 feet in height.

RESEARCH SUMMARY PUBLISHED

The Summary of Engineering Research 1968, a complete description of engineering research at the University of Illinois during the past year, has been published. It provides a concise survey of over 600 research projects including investigators, sponsors, and publications resulting from the research. The *Summary* is a useful reference to current work in the College for faculty members, graduate students, and researchers in industry and other universities. It is available without charge from the Engineering Publications Office. ◆

PEOPLE AND PLACES

Dean **William L. Everitt** will be the first recipient of the University of Michigan's Distinguished Professional Achievement Award. It was established to recognize those "whose contributions to the engineering profession have been distinguished and humane." The award will be presented at the University of Michigan's Mechanical Engineering Centennial Convocation. Dean Everitt will present a major speech as part of the convocation.

The American Society of Civil Engineers has awarded its annual Walter L. Huber prize to Civil Engineering Professor **H. S. Ang.** The prize is awarded to the younger members of the Society for their early accomplishments and to those who can be expected to continue fruitful careers in research. Professor Ang was cited for research of the applications of mathematical and scientific principles to the advancement of structural engineering practice.

Professor **Chester P. Siess** of the Department of Civil Engineering has been awarded the Ernest E. Howard Award of the American Society of Civil Engineers. The award recognized his contributions to the advancement of structural engineering in the area of prestressed reinforced concrete.

Director of the University's Traffic Safety Center, Professor **John E. Baerwald,** has been named administrative vice-president of the Institute of Traffic Engineers and president-elect for 1970. Professor Baerwald, of the Department of Civil Engineering, has been serving as technical vice-president of the international organization which has more than 3,500 members in 60 countries.

The American Institute of Ultrasonics in Medicine (AIUM) will sponsor an annual Fry Memorial Lecture in honor of the late Professor **William J. Fry.** Professor Fry, formerly of the Department of Electrical Engineering, was President of the AIUM for the past two years. The first Memorial Lecture was presented this month at the International AIUM meeting in New Orleans. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 4, DECEMBER 1968

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In the order listed, this issue contains articles on the following subjects:

A VEHICLE FOR QUADRIPLEGIC TRANSPORTATION
PLANS FOR A RADAR TELESCOPE
LASER STUDIES OF FLUORESCENT PLANTS
WATER PURIFICATION STUDIES

RAPID TRANSIT SIMPLIFIED

George Stupp is an honor student in the Department of Electrical Engineering at the University of Illinois, yet he will have unusual difficulty in finding suitable employment. George will have to take a job with housing very close to his work location. He is confined to an electrically powered wheelchair as a result of polio which left him with limited use of his hands and arms, and no use of his legs.

Two recent alumni of the General Engineering Department have produced a prize-winning solution to his dilemma. Their design of a vehicle for expressway transportation of a quadriplegic has won a $1,000 second prize in the Lincoln Foundation 1968 Student Engineering Design Competition. Gary Fariss and Burr Logeman designed a system which would allow George to operate a highway vehicle with the same dexterity, comfort, and safety as an able person.

The design includes both control and vehicle modifications which would cost an estimated $7,000. One-handed control is through a single "joystick" handle; two electrohydraulic servo systems connected to it actuate steering, brake, and throttle. This is similar to the control with which George handles his electrically driven wheelchair in buildings and on walkways. Since he cannot transfer himself from the chair to an automobile seat, provisions were also made to enable George to enter and leave the vehicle independently while remaining in the wheelchair, to lock it in place when inside, and to provide restraint for his upper torso.

Fariss and Logeman began work on this project last year when they were seniors in an undergraduate design project course. Many projects are carried on by successive classes; if funds can be obtained, this year's class is considering building a prototype of the student-designed vehicle. Then things should really get rolling, by George. ◆

MUSIC OF THE SPHERES?

The Midwest may get an excellent chance in the next few years to eavesdrop on the universe if the suggestions of a panel of aeronomy and radio astronomy experts are followed. After a year-long study, the panel has recommended the construction of a steerable radar telescope larger than any such instrument now in operation.

The telescope has been planned by scientists and engineers representing the Committee on Institutional Cooperation (C.I.C.), an association composed of the Big Ten universities and the University of Chicago. The chairman of the panel is Professor Sidney A. Bowhill, project director of the Aeronomy Laboratory in the University of Illinois College of Engineering.

The proposed dish-shaped telescope is 360 feet in diameter, steerable, and would be built under a giant radome cover. The largest comparable instrument now operating is the 240-foot-diameter radio telescope at Jodrell Bank in England. The cost of the new telescope is estimated at 20 million dollars.

The location for the telescope has not yet been selected, although five sites have been investigated by the panel. The final choice of the site would be dictated by its accessibility, freedom from radio interference, and its proximity to one of the C.I.C. schools. Supplementary equipment would be at two other locations, each approximately 200 miles from the telescope, situated so the three locations form an equilateral triangle. Once funds for construction are available, the actual construction of the telescope would take from three to five years.

The proposed telescope design is quite versatile. First it can be used for aeronomy, the relatively new field which studies the interaction between the ultraviolet rays of the sun and the earth's upper atmosphere. Other studies in this area yield information about the winds that move at high altitudes, the daily expansion and contraction of the atmosphere, and the geomagnetic "tail" which follows the earth on the night side.

The new telescope could also be used for gathering radar data about the surface features of nearby planets. These data could have many uses in later manned explorations. Another use for the telescope would be the study of radio signals originating in outer space. Recent discoveries of pulsars, extremely regular radio sources in the galaxy, suggest that more research is called for in this area. Because it is steerable, the new telescope would provide an excellent method of tracking these and other radio sources.

The multipurpose features of this installation would benefit the scientific community of the entire Midwest. University departments not primarily concerned with aeronomy would be able to use the facility in other types of research. Because of its location near large universities, the telescope would be useful not only for research, but also for stimulating student interest in these growing fields of study. The field of aeronomy in particular, and research and education in radio and radar astronomy in general, should benefit greatly from this big new "ear to the universe." ◆

A NEW WAY TO LOOK AT ENERGETIC PLANTS

One of the appealing things about university research is that every sort of expert and all types of equipment are available if you just know where to look. Recently on the Illinois campus a group of researchers in the life sciences were having difficulty measuring energy conversion rates in plant cells. Their major problem was that these conversions took place in one-billionth of a second or less, and they didn't have equipment capable of "seeing" these short-lived happenings. They took the logical step — into the Quantum Electronics Laboratory in the Electrical Engineering Building.

Professors Eugene Rabinowitch, Govindjee, and their colleagues were examining re-emission rates of light from plant samples. The efficiency of this photosynthetic process, which is indispensable to plant life, can be determined by putting in a known amount of energy (light) and measuring both the unused portion that is re-emitted (light again) as well as the rate at which it is re-emitted. In some plants the residual energy is emitted slowly, which makes it easy to measure. Other, more efficient plants throw off little excess energy (and at a rapid rate), which gives the researchers a far different sort of problem.

The researchers were studying the latter kinds of plants. Because the radiation was emitted in ultrashort lengths of time, they were unable to measure it accurately. The available strobe lights took so long to flash that the re-emitted plant fluorescence would die away before the flash lamp turned off. The relatively weak flash lamps also masked the emitted spectrum so that it could not be measured.

The researchers asked Electrical Engineering Professor Henry Merkelo if he could shed some new light on the problem. Working together, the electrical engineers and biologists replaced the flash lamp with lasers. These devices could provide exceptionally short pulses (about one-billionth of a second long) at a very rapid rate (one hundred million times a second) with light of a single frequency and a chosen color. Because of these shorter pulses, the laser light would vanish much quicker than the flash lamp while giving a more intense pulse; even durations as short as a few trillionths of a second could be accurately measured.

The biologist's problem was solved, and simultaneously, the electrical engineers had a new way of answering questions in quantum electronics, laser physics, and other areas. In chemistry, the energy transfer in some flourescent dyes can now be studied by using the laser as a light source. The laser is even being used to study a semiconductor laser to gain a better understanding of how the device works. In short, it appears that the laser will provide some illuminating solutions in a number of areas. ◆

ELEVENTH SANITARY ENGINEERING CONFERENCE

"Influence of Raw Water Characteristics on Treatment" is the title of the Eleventh Sanitary Engineering Conference to be held at the University of Illinois on February 5 and 6, 1969. The conference is planned for sanitary engineers in government, industry, and private practice, and water works managers and operators. It is sponsored jointly by the Illinois Department of Public Health and the Department of Civil Engineering at the University of Illinois. Further information may be obtained from John H. Austin, Associate Professor of Sanitary Engineering, 3230 Civil Engineering Building, University of Illinois, Urbana, Illinois 61801. ◆

CONCRETE BRIDGE BULLETIN

Engineering Bulletin No. 497, *Investigation of Prestressed Reinforced Concrete for Highway Bridges, Part V: Analysis and Control of Anchorage-Zone Cracking in Prestressed Concrete,* by W. A. Welsh, Jr., and M. A. Sozen introduces an analytic method for predicting the possibility of anchorage-zone cracking. It also presents a method of designing transverse reinforcement to control this cracking. Highway engineers and others interested in this 77-page Bulletin may obtain it from the Engineering Publications Office for $3.00 per copy. ◆

Professor John O'Connor and his assistant, Kalyanpur Baliga, inspect the sand filters in a water filtration pilot plant. The plant is part of a study to determine the effects of biological growths on the removal of iron from public water supplies.

WHAT COLOR IS YOUR COFFEE?

Bacteria, iron, and water have combined to provide University of Illinois civil engineering professor John O'Connor with a solution which is really a problem. These three ingredients can frequently join forces in water systems, creating conditions which result in rust particles in your morning coffee.

In many public systems water is pumped up to ground level and then aerated. When oxygen is present, the dissolved iron will react with it to form ferric hydroxide, or — as it is more commonly known — rust. After a period in settling tanks, the water is run through a sand filter to remove the now solid rust particles. The tiny, difficult-to-remove bacteria that grow on these filters remove the oxygen from the water, causing the rusty sediment to return to solution instead of being filtered out. Then the water is on its way through the distribution system to your tap, still carrying the iron.

In order to help O'Connor study this problem, a well has been dug at the Civil Engineering Building, and a filtration plant has been set up. As in larger filtration plants, periodic filter backwashing by reversing the flow of water is used to clean the bacteria from the filter. Those remaining re-establish themselves quickly. O'Connor is developing methods for removing the bacteria by a better backwashing system using an "airwash" which would mix the sand, or a chemical treatment of the filter with chlorine or permanganate.

Professor O'Connor is also studying whether the amounts of oxygen-depleting ammonia found in ground water from agricultural areas may be increasing because of the large amounts of nitrogen fertilizers used by farmers. Since the chemical reaction of ammonia and water results in the loss of oxygen, it also results in more iron held in solution.

If men like Professor O'Connor can't solve this problem, we may find that we have more iron in our water than iron in our water pipes. ◆

A MATTER OF DEGREES

Purdue, the University of Michigan, and the University of Illinois at Urbana-Champaign are the nation's top schools in the number of degrees conferred in engineering fields in 1967–68, according to a survey by the Newark College of Engineering.

Totals of all degrees — bachelor's, master's, and doctor's — in engineering fields for the top three schools are listed as: Purdue, 1,195; Michigan, 1,168; Illinois, 1,108. Next are the Massachusetts Institute of Technology, 1,071; the University of California at Berkeley, 1,041; and Georgia Tech, 1,004.

In engineering bachelor's degrees, the leaders are Purdue, 765; Illinois at Urbana-Champaign, 714; Georgia Tech, 692; Michigan and Newark College of Engineering, each 589. In master's degrees, the leaders are California at Berkeley, 496; Michigan, 466; M.I.T., 462; Stanford, 564. The top producers of doctorates were: M.I.T., 154; Stanford, 146; California at Berkeley, 116; Michigan, 110; Illinois at Urbana-Champaign, 103. ◆

TALKS TO COVER THE WATERFRONT

The University of Illinois has been selected as the location for the first International Seminar for Hydrology Professors. The seminar, under the direction of U of I Hydraulic Engineering Professor Ven Te Chow, will acquaint the educators with new technological developments. They will also discuss the current needs and problems of higher education and explore new directions for hydrologic teaching and research.

Participants in the seminar will represent a worldwide selection of hydrology professors, as well as leading government and consulting hydrologists. The series of International Seminars is a major contribution to the International Hydrologic Decade — a United Nations program to promote international cooperation and coordination of education and research in the science of water use and its application. More than 100 nations have been participating in this endeavor since 1965. ◆

NEW HONOR FOR BARDEEN

University of Illinois Physics Professor John Bardeen has been awarded the Michelson-Morley Prize for his "development of the theory of superconductivity leading to new insights into collective electronic phenomena in solids." The award from Case Western Reserve University also mentioned his pioneering efforts in the area of semiconductor phenomena, which led to the discovery of the transistor.

Professor Bardeen is a distinguished Professor of Electrical Engineering and Physics at the Center for Advanced Studies at the University of Illinois. In 1956, he shared the Nobel Prize with two associates for their work on semiconductors. This research heralded the use of the transistor in a wide variety of consumer and industrial products, replacing the bulky vacuum tubes then in use.

The $5,000 Michelson-Morley Award is named for Albert A. Michelson, formerly of Case Institute of Technology, and Edward W. Morley of Western Reserve University, who collaborated on a well-known experiment that contributed to the verification of Einstein's theory of relativity. ◆

PEOPLE AND PLACES

The announcement of a $50,000 gift to establish a visiting professorship was made at the annual meeting of the University of Illinois Foundation. The Harold Earle Thompson Visiting Professorship in Electrical Engineering honors the late **H. Earle Thompson,** who was a member of the Foundation for many years. The award will provide for a distinguished faculty visitor, selected by a departmental committee, to be in residence at the Urbana campus for at least four weeks, to participate in class and laboratory work, to make at least one major public address, and to be available for consultation.

Dean Emeritus **William L. Everitt** of the College of Engineering was an invited speaker for the third Pan American Meeting held December 2-6 at the Federal University of Rio de Janeiro at Guanabara, Brazil. He spoke on the relationships between graduate and undergraduate engineering education. The meeting is one of a series of conferences on graduate engineering education sponsored by the Pan American Union to aid the expansion of advanced professional engineering training in Latin America.

Mechanical Engineering Professor **William Hull** has been elected to a three-year term as a member of the Board of Directors of the Society of Automotive Engineers. The 26,000-member organization sets standards, encourages research, and provides information exchange for nearly all types of transportation. Hull, who has been active in the S.A.E. since 1936, has held various posts in its Central Illinois Section, including the chairmanship. He organized student branches at the University of Colorado in 1944, and at the University of Illinois in 1949, and was faculty advisor for both groups. ◆

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 5, JANUARY 1969

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In the order listed, this issue contains articles on the following subjects:

A COMPUTERIZED URBAN STUDY
REPRINTS OF TECHNICAL REPORTS
A COMPUTER-BASED EDUCATION SYSTEM
BIOMECHANICS RESEARCH ON THE HUMAN HEAD
A CIVIL ENGINEERING AWARD

FROM VILLAGE — TO TOWN — TO CITY

A city in north central Illinois is the world's first to have the factors affecting its past growth comprehensively analyzed by electronic computer. In a project of the U of I Coordinated Science Laboratory, Urban Planning Professor Jerrold R. Voss and Physics Professor Leo P. Kadanoff are using an electronic computer and computer graphics to analyze data and draw maps showing changes in land value and use in Kankakee since 1854. Through cooperation of Harold L. Nally, Kankakee County recorder of deeds, and Henry W. Wulffe, Jr., of the Kankakee Title and Trust Company, information on date, type, and sale price of each real estate transaction from 1854 to the present in alternate city blocks has been collected on more than 70,000 punched cards, from which it is being transferred to magnetic tape. Additional information used in the project includes transportation, sewer and water facilities, parks, schools, industry, churches, social and economic status of the residents, and their ethnic and racial characteristics.

These data, reflecting the city's year-by-year changes, will permit an unprecedented and highly flexible analysis of changing land use and an opportunity for projecting alternatives for future development. They provide an "opportunity to move away from static models of urban growth and into modeling cities as they actually are — dynamic processes of growth and decay," to use Professor Voss' own words. "We will try to develop an understanding of how various blocks and sub-areas of the city changed through time and, simultaneously, view these changes in the light of changing transportation, economics, and other factors."

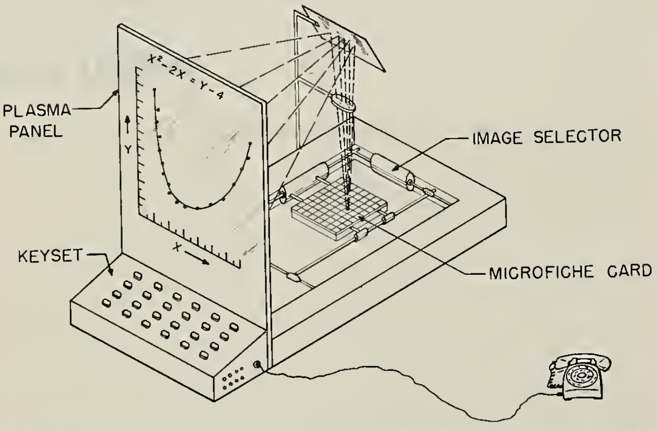
Kankakee will be the first city to have detailed information about its own growth, from which theories about urban development and change can be tested and potentials for future development projected. The study, for which the Ford Motor Company is providing part of the financing, began six months ago and will take two years to complete. ◆

WHEN IS A REPORT NOT A REPORT? WHEN IT'S A CLASSIC!

It has been said that the average life expectancy of a technical report is about the same as that of a tail gunner in World War II. But just as some tail gunners survived to live to a ripe old age, so do some technical reports.

It is not as unusual as one might imagine for the College to receive requests for reports that were produced fifteen or twenty years ago. Because such documents are usually printed in limited quantities, such orders cannot ordinarily be filled, and at times it is not even possible to tell the requester where he can get one from a library. Technical reports that create this kind of demand are admittedly rare. Most reports are intended to be semi-private communications between researcher and sponsor, whereas resulting data worth communicating to others are published in technical journals. But once in a great while a report appears that contains information that for one reason or another does not appear in the journals, sometimes because there are just too many important data to permit an article of journal length to be written. These are the reports that become popular, and occasionally their popularity exceeds their availability by many years.

The Engineering Publications Office has devised a system that provides information about which U of I engineering reports are still in demand, and this feedback is used to decide which of them should be reprinted and made available again. Each report is handled as a separate title and offered at a price that approximates the cost of reproducing it. Over the last two years a number of reports that were in great demand have been reprinted, and the program appears to be successful. Additional reprints will be listed in *Outlook* as they become available; here's a chance to start your own library of classics. ◆



A student terminal for the PLATO IV computer-based education system can have an image projected on its plasma panel or have information displayed electronically. Professors Donald Bitzer and Dominic Skaperdas are in charge of the project, which will place four thousand terminals in operation by 1974.

FOUR THOUSAND STUDENTS AND A COMPUTER

The little red schoolhouse with its quaint belltower and one-room thinking is a relic of an era long past in education. Its modern counterpart of stainless steel and glass may become a symbol of a time just as remote, when a computer-based education system being developed at the University of Illinois has its four thousand computer-controlled student terminals installed in Illinois schools.

Professor Donald L. Bitzer and Dominic O. Skaperdas, director and associate director of the University's Computer-based Education Research Laboratory, are guiding research in the six-year PLATO IV project and have already established PLATO demonstration centers in four schools. The PLATO system (PLATO stands for "Programmed Logic for Automatic Teaching Operations") has been in operation at the University of Illinois since 1960. It started with a single student station, added a second, and now operates twenty stations at once. Teaching has been at levels from kindergarten to graduate; subjects have included mathematics, chemistry, biology, library science, electrical engineering, and nursing.

Bitzer and Skaperdas said each of the four thousand student stations will have a 12-inch-square panel on which one image can be presented electronically while another is superimposed by projection through the glass. The projected images are formed by a 4-inch-square film which may contain 256 or more color images. A lengthy book could be placed on two slides; an entire unabridged dictionary could be stored on less than a dozen. Both electronic and slide images will be controlled by a large central computer which can also control selected motion pictures for projection on the panel and sound tapes for use with the student station.

The central computer will offer several different lessons at the same time. Each of the four thousand students will select his own lesson and progress at his own speed. Through an electric typewriter he will control his own display, write answers into the display, "turn pages" ahead or back, ask the computer for extra help over the sticky parts, and even demonstrate flashes of insight by punching an "Aha!" button when he understands the computer's additional help.

The key to economic development of the proposal is the plasma display panel, invented by D. L. Bitzer, H. G. Slottow, and their associates in the U of I Coordinated Science Laboratory. The panel, resembling a television screen, is an inexpensive display which combines simple structure, high brightness, and the ability to display words, drawings, mathematical problems, or other visual material electronically. It can change the display almost instantaneously and "remember" the display automatically until another change is directed. In contrast, the image on a cathode-ray tube or television screen is constantly renewed by a fast moving electron beam, which contributes considerably to the complexity and cost of this type of display device.

Essentially, the plasma panel consists of three sheets of glass; the center one contains a grid of tiny holes filled with a gaseous plasma which can be made to glow brightly under control of transparent conductive strips on the outer glasses. The U of I and commercial firms licensed by it are working on the development and application of the panel.

The presentation of the projected image posed a problem. Because of its extremely small size, each "page" of the slide must be exactly positioned to project onto the panel in the right location. This required the development of a rapid and accurate slide selector which could find any given page on the slide, position it correctly to a few thousandths of an inch, and project it, all within the time it would take a reader to turn the page of a normal book.

Although PLATO will not render the book and the teacher obsolete in the foreseeable future, the riffling of papers that accompanies the beginning of a lesson may be replaced by the sound of switches being turned on. ◆

FOR HEADS UP RESEARCH — A SKULL SESSION

As any engineer can tell you, research that has definite impact is hard to come by. Graduate research assistant Marvin Janssen of the U of I Department of Theoretical and Applied Mechanics is supplying his own impact in a biomechanics study of the stresses that are developed when the human head is struck.

Previous studies have suggested that direct hydrostatic pressure from a blow to the head is not usually the primary cause of brain damage. Shear stress, caused when two adjacent portions of the brain slide in relation to each other, severe acceleration, or cavitation (the formation of a partial vacuum in the brain), are much more likely to cause damage that may result in death or lasting injury.

Janssen is developing a model of the head that can be used to study these effects. His current model represents a two-dimensional "slice" of the head and is constructed from a plastic skull filled with a thick gelatin that simulates the consistency of the brain. Both the plastic and the gelatin are birefringent materials. When they are illuminated with a brief but intense flash of light and viewed through a polarizing filter, the stress caused by an impact of known strength is visible as a series of brightly colored interference fringes. These fringes show the distribution of shear stress and provide an accurate measure of its strength.

The dynamic response of the model is determined by taking photographs of the stress patterns at varying times after the impact. Using repeated impacts and suitable time delays, a series of sequential photographs captures the rapidly changing stress pattern for later study.

Although his present replica of the head is a simplified one, Janssen says that there are several ways in which it might be improved. As the model is further developed, it might include an additional material coating on the outside of the plastic "skull" to simulate the cushioning effect of the hair and scalp. Additional research may uncover new birefringent materials whose properties more closely resemble those of the brain and skull. The model might be further improved by representing the entire skull and its contents, rather than just a slice through the head.

Janssen's project is part of a larger program, under the direction of Professor C. E. Bowman, to develop a mechanical model of the human head which can be used to evaluate head-protection designs. An accurate model could answer questions such as these: How well does a padded automobile dash protect the head? What type of helmets provide the motorcycle rider with the best protection from brain damage? Results from this biomechanics research may someday allow safety engineers to answer these questions without having to use their heads to prove their contentions. ◆

Research Assistant Marvin Janssen examines a model of a portion of the human head in order to learn more about the mechanics of head injury. The photoelastic model can be used to locate and measure the stress caused by an impact.

CIVIL ENGINEERING AWARD

A $500 annual award for an outstanding civil engineering student, graduate or undergraduate, at the University of Illinois has been established in memory of the late W. E. O'Neil, founder of the O'Neil Construction Company of Chicago. A $10,000 endowment for the award has been presented to the University of Illinois Foundation by A. F. O'Neil, son of the founder and now president of the company. The first award will be made next spring.

The honor was established at the University of Illinois in recognition of contributions which the Department of Civil Engineering has made to construction engineering procedures and management. The purpose of the award is to stimulate interest and encourage excellence of students in civil engineering. Selection will be on the basis of scholarship, interest, and potential. Preference will be given to a student specializing in construction management.

If he is an undergraduate, the winner will be selected by the Head of the Civil Engineering Department with approval of the Dean of the College of Engineering, or, if the candidate is a graduate student, the Dean of the Graduate College. To be eligible, students must have completed no less than five semesters of academic work, and must intend to complete requirements for a degree in civil engineering. ◆

PEOPLE AND PLACES

Civil Engineering Professor **Chester P. Siess** has received the Howard Medal of the American Society of Civil Engineers. Professor Siess was cited for his contribution to the advancement of structural engineering through his extensive research, teaching, and writing about reinforced concrete.

The fifteenth Emile Berliner Award of the Audio Engineering Society has been presented to Professor **Duane H. Cooper** of the Coordinated Science Laboratory and the departments of Physics and Electrical Engineering. The award, named for the inventor of the disc phonograph, is given annually for an outstanding development in audio engineering. Professor Cooper was honored for his analyses of acoustic distortions in the playing of phonograph records.

Professor **Alfred W. Allen,** Department of Ceramic Engineering, has been elected president of the Ceramic Educational Council. The Council has 250 members representing 75 institutions in the United States. It was established formally in 1921 to promote and improve education in ceramics with emphasis on ceramic engineering and science.

Dean **Daniel C. Drucker** and Civil Engineering Professor **William J. Hall** were panelists at the session on Applied Mechanics at the eighty-ninth annual winter meeting of the American Society of Mechanical Engineers held December 1–5. Dean Drucker presented a paper, "Plasticity Fundamentals of Fracture." Professor Hall's paper was on "Comparison of Fracture Testing." ◆

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URBAN CLIMATE STUDIES
A THEORETICAL EXAMINATION OF ORNITHOPTERS
NATIONAL MEDAL OF SCIENCE AWARD
WASTEWATER TREATMENT
ORDER FORM FOR NEW PUBLICATIONS

A NEW KIND OF MODEL CITIES PROGRAM

Although major modern cities probably have the healthiest environment ever developed for close human habitation, several major air pollution "episodes," among other things, have graphically demonstrated that they are far from ideal. Urban biometeorologists have been devoting increasing amounts of time to the problem of predicting and controlling air pollution, but are faced with the difficulty of understanding the urban climate. In order to achieve better prediction and control of concentrations of air-borne pollutants, much better measurements must be made of atmospheric stability above the city.

Although most pollutants are encountered in a relatively narrow layer of the atmosphere (usually less than 600 feet), there is still little information about the local conditions of the climate within this layer. The problem lies in the fact that it is difficult and expensive to take accurate wind and temperature measurements in this layer. The advent of the television tower has provided one means of taking measurements, but unfortunately, at least from the meteorologists' view, there are all too few instrumented television towers in American cities.

Some studies have been made, but because they were done in specific cities, generalization of their results to other areas will be strongly dependent on the terrain and shape of the city. M. L. Davis, a former graduate student in Sanitary Engineering at the University of Illinois, was interested in finding ways to permit the needed information to be gathered and applied to any urban area. He began investigating the possibility of developing models of the city and studying them to determine the city's effect on the climate.

He started by selecting an open field near the Champaign-Urbana campus. The field resembled the flat terrain of Fort Wayne, Indiana, the city he had chosen to model. Initial studies had shown that cities may be as much as 30 per cent warmer than the surrounding rural areas, due to their greater human activity and heat "leakages" from urban buildings. In order to simulate this effect of the urban heat island, Davis buried electrical heating cables a few inches beneath the site chosen for the model.

The next problem had its ups and downs; not only is there a heat difference between urban and rural areas, but there is also a decided difference in roughness between the flat Indiana plain and the buildings of Fort Wayne. This difference has a noticeable effect on their climates. He duplicated this roughness — caused by buildings, residences, signs, and so on — with ordinary building laths. Nearly 2,500 pieces of lath were cut to form 17,000 hand-placed "roughness elements" which simulated the general topography of the city rather than providing an exact scale model. A residential area was simulated by a group of 3-inch laths; buildings in business districts were modeled by laths about 5 inches high.

Since the raw wood did not reflect sunlight in the same way as the more darkly colored buildings in Fort Wayne, they were treated with creosote, which darkened them and made them more resistant to the climate at the model site. The entire model was built over tar paper which simulated the radiation characteristics of the ground in Fort Wayne. The complete model covered an area 30 feet square.

Now Davis dealt with the problem of measuring the temperature above the model. Since a height of many feet above Fort Wayne was comparable to a few inches above the model, he had to devise a method of measuring the temperature at an exact point above the model. His solution was a thermopile. This sensitive device is composed of pieces of dissimilar metal soldered together; it develops a voltage which is proportional to its temperature. It was compact enough to allow accurate measurements to be made for temperature differences of less than a degree at distances of 2 inches.

His model now completed, Davis spent many nights of the next four months taking data from the model. Although his model proved to be less than perfect, it indicated that modeling is a promising method of studying the effect of the city on its own climate. Some of the observed atmosphere instabilities noted over Fort Wayne were successfully duplicated over the model. No longer will the sanitary engineers have to conduct their studies of the urban atmosphere with their heads in the clouds. Thanks to the mini-city model, future studies can be made with both feet on the ground. ◆

THE SOUND OF ONE WING FLAPPING

Since the beginning of time man has dreamed of flying, and some of his early efforts to imitate the birds were ingenious and occasionally comical. But even today, in a time when he has not only left the ground, but also the planet, he has still not been able to produce a flying machine that obtains thrust by flapping its wings — an ornithopter.

Because most of these attempts have been the work of amateur inventors and enthusiasts, there has been little attention given to the aerodynamics of flapping-wing flight. U of I Astronautical and Aeronautical Engineering Professor A. I. Ormsbee and graduate student George Bennett are beginning a scientific study of the aerodynamics of ornithopters.

In order to understand the forces acting on the ornithopter in flight, they are developing a mathematical model of a flapping wing — an extension of an existing aerodynamic model. While there are little experimental data for wings undergoing large flapping motions, some experimental data for wings undergoing flutter and rotational motion are available. Later, the researchers will build a single flapping wing, which will be tested in a wind tunnel to check the correctness of their theory.

An ornithopter is attractive for study because of its special characteristics. It is able to perform all the maneuvers of a helicopter, but in forward flight would have a higher efficiency. It would also fly much more quietly, and would possibly be useful in military reconnaissance. The study will provide biologists with ideas about how some birds migrate distances of over 600 miles without stopping, and also provide insights into the energetics of insect flight.

With methods of flight efficient enough to take him to the moon, man still does not know exactly how nature's aviators fly so well. Our fine feathered friends do not know themselves. While they are certainly airworthy, they also have birdbrains. The Illinois study will show whether man's larger brain can compensate for his lack of natural flying ability. ◆

Professor Nathan M. Newmark stands beside a photograph of Mexico City's Latino-Americana Tower. Newmark was recently honored with the National Medal of Science for his work as the Tower's earthquake design consultant and for his many other outstanding achievements.

AN AWARD FOR A TOWERING ACHIEVEMENT

On July 28, 1957, Mexico's worst earthquake in 50 years devastated Mexico City. A dozen buildings collapsed and many more were so greatly damaged that they would have to be demolished. Amid the rubble the city's tallest building, the Latino-Americana Tower, stood unharmed. Not a window or a partition in the giant building was cracked.

— *Men and Ideas in Engineering*

A plaque attached to the tower recognizes U of I Professor Nathan M. Newmark for his role in the building's success as its earthquake design consultant. For this and other achievements in structural dynamics he was honored with the National Medal of Science, which he received from President Johnson in a White House ceremony. The citation accompanying the medal, the nation's highest award in engineering, mathematics, or science, said, "His demonstration that such buildings can be built to a height of 40 or more stories, instead of being limited to 10 or 12 stories as required by some building codes, has had far reaching consequences in engineering practice."

Newmark received his B.S. degree in civil engineering from Rutgers University before the age of twenty. He received the third Ph.D. in civil engineering awarded at the University of Illinois. From 1930 to 1947, he did research on developing practical methods for the design of structures against such variable and unpredictable events as earthquakes and blasts. In 1947, he was named Chairman of the Digital Computer Laboratory, a post he held for ten years. As chairman, Newmark organized the digital computer program and administered it during the construction and operational phases of setting up the first large-scale computer group at a university.

In addition to his continuing professional contributions, Newmark has developed an impressive Department of Civil Engineering at Illinois and achieved world-wide recognition as a consultant. In 1955, he was awarded an honorary Doctor of Science degree from Rutgers; he received the degree of Doctor Honoris Causa from the University of Liege in Belgium in 1967. A founding member of the National Academy of Engineering, he is also a member of the National Academy of Science. ◆

THICKENING THROUGH THE WASTE

A big city may not be the only place where workers who are supposed to remove the waste become a problem when they get unmanageable. Microorganisms, the biological workers used in wastewater treatment processes, must be dealt with so severely as to dispose of some of them. In a favorable environment they might multiply to such an extent as to become a problem.

Every body of water contains a certain number of microorganisms which live on organic carbon compounds. In "clean" water — like our tap water — they have little chance of survival because of lack of food. In a healthy lake, they may find just enough food to survive and do their work of removing pollutants and thus maintain a healthy balance between their food supply and their own number. However, in wastewater treatment the sanitary engineer has created a favorable environment that causes them to increase rapidly and to develop into a biological sludge which is difficult to remove.

The conventional wastewater treatment utilizes various methods of thickening the waste organisms so that they can be disposed of economically and with minimum hazards to health. But this process of sedimentation and thickening of the sludge into a compact mass does not work well with the biological sludges, because the microorganisms are extremely light and highly flocculent and therefore resist consolidation. With financial support from the Federal Water Control Administration, Civil Engineering Associate Professor Richard I. Dick is directing research to help solve this problem faced by many waste treatment and water treatment plants.

Prevailing theories on gravity thickening are inadequate in their description of the settling behavior of these flocculent sludges, and existing gravity sedimentation tanks do not work well either. Dr. Dick is trying to develop design criteria for sedimentation tanks that take into account the peculiar properties of biological sludges such as their jelly-like consistency, their great volume as compared to their light weight, and interparticle forces that prevent consolidation.

The nature of the microorganisms could be changed in order to render them more amenable to treatment. With the aid of a rotational viscometer which monitors changes in the physical characteristics of the biological solids, the effect of changes of environmental conditions in waste treatment processes, under which the organisms grow, are being evaluated.

ORDER FORM FOR NEW PUBLICATIONS

☐ Bulletin 497, *Investigation of Prestressed Reinforced Concrete for Highway Bridges, Part V: Analysis and Control of Anchorage-Zone Cracking in Prestressed Concrete* by W. A. Welsh, Jr., and M. A. Sozen. *$3.00.*

☐ Bulletin 498, *Prediction of Creep in Structural Concrete* by E. M. Wallo and C. E. Kesler. *$3.00.*

☐ Bulletin 499, *Fatigue of Concrete* by J. P. Lloyd, J. L. Lott, and C. E. Kesler. *$2.00.*

Other publications:

☐ Catalog, *A Listing of Engineering Publications, 1904-1969. No charge.*

☐ *A Summary of Engineering Research, 1968. No charge.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois. *No charge.*

☐ *Men and Ideas in Engineering,* hard bound, 58 photographs, 10 diagrams, 164 pages. *$5.00.**

Send with remittance to Engineering Publications, 112 Engineering Hall, Urbana, Illinois 61801.

*** Illinois residents please add 5 per cent sales tax.**

The disposal of waste, or sludge, produced by treatment processes of water-borne waste represents a sizeable fraction of the total cost of waste treatment. This cost can be reduced, once Dr. Dick's research shows those recalcitrant microorganisms how to consolidate. ◆

. . . WHICH NOBODY CAN DENY

University of Illinois Professor James O. Smith of the Department of Theoretical and Applied Mechanics has been honored with election to the grade of Fellow in the American Society of Mechanical Engineers. Professor Smith received his certificate of membership at the Society's annual meeting. To qualify as a Fellow, a nominee must be an engineer with acknowledged engineering attainment, have twenty-five years of active practice in engineering or engineering teaching, and be a full member of the A.S.M.E. for thirteen years.

Professor Smith was honored not only as a great teacher of engineering but as a leader in his profession. His widely adopted textbooks have contributed to the understanding of analysis and design and have set a new standard in clarity and breadth of coverage. In 1967 the American Society of Engineering Education honored him with the Western Electric Fund award for his excellence as a teacher. ◆

STUDENTS PLAN LOOK-IN

Open classes and student displays will highlight the annual U of I Engineering Open House on March 7 and 8. In addition to displays of engineering projects, this year's Open House will continue the successful visitation program begun last year. Outstanding juniors from Illinois high schools will attend engineering classes and discuss careers in engineering with faculty members. The public may examine displays and tour the Engineering Campus on both days. For further information, contact Engineering Open House, 300 Engineering Hall, U of I, Urbana, Illinois 61801. ◆

. . . BUT FOR YOU, 498 AND 499

Two new Engineering Experiment Station publications describe the behavior of concrete under varying loads. Bulletin No. 498, *Prediction of Creep in Structural Concrete,* by E. M. Wallo and C. E. Kesler, examines the major factors which cause creep and shrinkage in structural concrete and presents a method of prediction based on them. Bulletin No. 499, *Fatigue of Concrete,* by J. P. Lloyd, J. L. Lott, and C. E. Kesler, considers recent research and the present state of knowledge on plain concrete subjected to repeated flexural loading, a condition of particular importance in the design of many highway structures. Copies of Bulletin No. 498 ($3.00) and Bulletin No. 499 ($2.00) are available from the Engineering Publications Office. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 7, MARCH 1969

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In the order listed, this issue contains articles on the following subjects:

AN INFRARED LIGHT CONVERTER
HEAT REGULATION IN SPACE SUITS
A REPORT ON THE NUCLEAR ENGINEERING PROGRAM
UNDERGRADUATE RESEARCH IN CIVIL ENGINEERING
RESEARCH BULLETIN NO. 500
A COMPUTER-AIDED DESIGN WORKSHOP

MANY HANDS MAKE LIGHT WORK

Ever since Archimedes jumped from his bath, invention has been thought of as the result of the thought and work of a single, hard-working individual. It doesn't often work that way anymore: technology has made the lonesome inventor a relic of a passing age.

The case in point is a study of infrared light detection at the U of I Coordinated Science Laboratory. The infrared light from night sky glow is almost as strong as the visible light from the moon. Since many objects reflect infrared light — which can't be seen by the human eye — just as they reflect visible light, C.S.L. Director W. Dale Compton wondered if it might be possible to build a lightweight, screen-like infrared viewer. Since he was an expert in the area of solid-state electronics, it was only natural that he should suggest a solid-state infrared-to-visible light converter.

His idea seemed simple enough. Infrared radiation would strike a semiconductor (the stuff transistors are made of), cause a small current to tunnel through an ultra-thin insulating material, and be injected into a phosphor (cadmium sulfide). Once in the phosphor, the injected current would cause it to emit visible light. By looking into the phosphor side of the converter, the viewer could "see" the infrared light striking the semiconductor side. But, as the proverb goes, there is many a slip 'twixt cup and lip; or in this case, 'twixt semiconductor and phosphor.

First, there is the problem of constructing an ultra-thin insulator only 50 angstroms thick. A stack of 15,000 would almost equal the thickness of this page of paper. In addition to this problem, the insulator needed would have to have a relatively large surface area but be free of holes, a common problem encountered in making thin films.

Even after the insulators are constructed, there remains the problem of understanding exactly how they work. Graduate assistant Steve Depp has started conducting studies on the properties of tunneling barriers. This part of the research has wide implication beyond the present project; the increasing popularity of solid-state devices has created a growing interest in thin-film behavior.

Once the problems of the middle are solved, there remain those of both ends. Electrical Engineering Professor George Anner is studying the basic properties of tunnel injection devices using single-crystal semiconductors similar to those which may be used in the converter. Professor R. N. Peacock, now in charge of the experimental phase of the project, is studying the light-emitting properties of a phosphor film excited by an injected current.

When all these studies are completed, the researchers hope to be able to build the converter itself by bringing all their background knowledge to bear on its construction and operation. In the process, they will have gained an understanding of solid-state phenomena which will apply to many devices other than the converter.

One of the things this project makes clear is the reason for the demise of the lonely inventor. Projects like this one are simply too complex for one man to be able to solve all of the problems. The team research concept illustrated here, which makes use of many different kinds of specialists, is by no means new — but then neither is the fact that, as in the past, one man has the original idea. Dr. Compton's converter is indeed an original idea, and it will be interesting to see whether a team of 13 experts working together can turn it into a reality. ◆

A water-cooled undergarment is fitted to a test subject as part of a research project on heat regulation in space suits. The study is being conducted in the Department of Mechanical Engineering.

NO SWEAT — WELL, MINIMUM PERSPIRATION

During the space missions there are considerable amounts of time during which the astronauts must wear EVA (Extra Vehicular Activity) suits. While science fiction has come up with some amazing suits in the past, it is an engineering reality that in the present many design problems still remain.

One important function of a space suit is the regulation of temperature to provide comfort for the astronaut and to ensure his survival. There are several basic approaches to the problem, and professors John C. Chato and Bruce A. Hertig of the University of Illinois Department of Mechanical Engineering are conducting investigations of some of these methods.

One way of achieving temperature regulation in a space suit is by direct cooling of the skin by an artificial means. In this case there would be little thermal stress, and consequently a minimum of sweating. A possible heat-removal idea is the "heat pipe," which would absorb heat from the inside of the space suit and transfer it to the environment. This system will work well in zero gravity situations.

In some of their experiments, Chato and Hertig use water shower techniques for uniform cooling of the body. Water cooling is easy to use, easy to control, and makes measurements of the sweat loss fairly easy to calculate, but even with the coldest water that can be used while the subject is still comfortable it does not cut down sufficiently on sweating. Water-cooled tubes in "cooling patches" are also used, to measure cooling effects on certain parts of the body. Possibly a cooling garment with separate water circuits for various body parts would be more efficient than one with uniform cooling; it, too, is being tested.

Sweating is a natural process in the human body, its primary function being to cool the body by evaporation when there is thermal stress. Another way to keep cool in a space suit is to evaporate sweat, just as you would in other more natural environments. But in a natural environment, the sweat would be lost in the atmosphere; in a space suit it is trapped inside unless a moisture-removal system is provided. A plate of porous material, called a sublimator plate, can be built onto the suit. Then, because of extremely low outside pressure, ice forms on the external surface of the plate. Inside the suit, water vapor condenses on the cool surface and then moves through to the outside. The thickness of the layer of ice would vary with the amount of water vapor being removed from the suit. The system is beautifully simple and self-regulatory.

Space technology takes in many areas of study. During Apollo 8 the astronauts wished it had included studies on curing the common cold. So far a cold in space is the same as a cold on Earth, but cool for space is being improved. ◆

AND A PURPLE PEAR TREE

A recent report compiled by the Oak Ridge Associated Universities shows the outstanding position of the University of Illinois in the nation's educational programs and facilities in nuclear science and engineering. The eighth such report, prepared under contract with the nuclear education and training division of the U.S. Atomic Energy Commission, lists 261 institutions active in the field.

Under "special facilities and programs," the U of I was listed for programs ranging from reactor system dynamics to health physics. A tabulation of facilities included the 1,500 kilowatt TRIGA reactor, four subcritical reactors, three particle accelerators, an electrostatic generator, the two large IBM computers, the home-grown ILLIAC computers, and. . . .

The report also mentioned the sixty available nuclear courses, the expanding work in nuclear physics at the master's level at the Chicago Circle campus, and the close cooperation between the University and Argonne National Laboratory. ◆

RESEARCH GOES UNDERGRAD

Research has been described as one of man's most frustrating, demanding, and rewarding endeavors. Typically, the frustrations, demands, and rewards have been largely confined to the faculty and graduate students. However, the U of I Department of Civil Engineering has completed its second year of twelve-month undergraduate research projects and its tenth successful year of an undergraduate research program.

The program, supported in part by the National Science Foundation, allows undergraduate civil engineering students to work through an entire calendar year on civil engineering research. The students are not technicians; they select their own topic, plan their own program, and perform their own research. The project begins in the spring semester, and continues through the succeeding fall. During the regular semester, the undergraduate researcher takes a normal amount of course work and spends about ten hours a week on his project. The summer months are devoted to full-time research; the student is supported by a research stipend.

Contact between the student and his advisor is on a one-to-one basis, a capable but inexperienced young researcher learning directly from an experienced research engineer. In the beginning, when the problem is being defined, they work together closely. As the student increases his knowledge and confidence, the amount of time he spends with his advisor declines. As he gains experience, the student develops an attitude of inquiry. He learns to question established practices, to view each process in analysis and design as susceptible to change, and to identify, formulate, and solve problems.

The quality of performance varies from student to student. Many find it difficult to start, hard to organize a relatively long-term study without the day-to-day routine of the classroom. Others have trouble stopping, limiting the scope of their study, and producing a report. However, almost all students develop an understanding of the importance of research and come to view scholarship as a means of gaining knowledge and understanding rather than a means of passing a course or obtaining a degree.

There are other, equally important, results of the undergrad research program. It discovers and encourages those undergraduates who have potential for advanced study and research. Of thirty-one students in the past three years, twenty-one have enrolled in graduate school. Of these, nine received fellowships, and eight others have received assistantships. In addition, the program is encouraging interest in research among other civil engineering undergraduates — who would also like to share the frustrations. ◆

BULLETIN NUMBER 500

Fifty-five years ago, when Arthur Newell Talbot wrote the first U of I Bulletin, he little suspected that his would be only the first of a series that would eventually reach 500 numbers and cover such widely differing areas as the Dewey decimal system and headlight glare. The five-hundredth Engineering Experiment Station Bulletin, *Restraint Characteristics of Flexible Riveted and Bolted Beam-to-Column Connections,* by C. W. Lewitt, E. Chesson, Jr., and W. H. Munse, describes the moment-rotation characteristics of beam-to-column connections. It makes recommendations for incorporating restraint characteristics in designs, saving beam weight by as much as 6 or 7 per cent.

For those interested in structural design and too eager to wait for Bulletin 1000, Bulletin 500 is available from the Engineering Publications Office for $3.00. ◆

URBANA GRADUATES SHOOT FOR THE MOON

At least 19 graduates of the University of Illinois at Urbana-Champaign were involved in development of the Saturn rocket to be used to launch American astronauts to the moon, according to a statement from the National Aeronautics and Space Administration's George C. Marshall Space Flight Center.

They earned degrees in ten fields at the University: political science, astronomy, physics, law, mathematics, engineering mechanics, and in aeronautical, civil, electrical, mechanical, and metallurgical engineering.

They are among the scientific and professional employees of the center at Huntsville, Alabama. Their work in the most complex scientific and technological effort the nation has ever undertaken contributed to the launch of Apollo 8 and is a part of the Apollo program working for a manned lunar landing before the end of 1969. ◆

DESIGN COURSE IN JUNE

The University of Illinois Department of Mechanical and Industrial Engineering, in association with the Office of State Technical Services, will sponsor a Computer-Aided Machine Design Workshop on June 2-6, 1969. Under the direction of professors Carl Larson and Wayne Adkins, the workshop will present computer techniques which can help the industry engineer make effective and reliable designs. It will provide a practical approach; participants will solve several design problems using U of I computers and special programming languages.

For additonal information, contact Dr. M. K. Blanchard, Coordinator of University-Industrial Relations, College of Engineering, University of Illinois, Urbana 61801. ◆

A MESSAGE TO GARCIA . . . AND ALL YOU OTHERS OUT THERE

Although most readers of *Engineering Outlook* aren't nearly so hard to locate as Garcia or Livingstone, it can be difficult when you are moving or otherwise changing your address. When requesting a change of address it would be extremely helpful if you included your old address and zip code as well as your new ones. Your old address, in the form of the mailing label on the back of each issue, will help keep *Outlook* up to date so that *Outlook* can help you keep up to date with engineering research and news at Illinois. ◆

PEOPLE AND PLACES

An internationally recognized solid-state physicist, **Charles P. Slichter**, has been named as the 1969 recipient of the Irving Langmuir Prize in chemical physics. He is cited for "his innovations in the applications of magnetic resonance techniques to the understanding of the structural and dynamic properties of matter." At the U of I since 1949, he was named a member of the Center for Advanced Studies in 1968, the highest recognition the University can bestow on a faculty member. In addition to his work on a wide variety of problems with impact in a broad area of chemistry as well as physics, he is a member of the President's Science Advisory Committee.

"For inspiration to others in improving man's environment and specific contributions to the advancement of engineering knowledge of structures subjected to earthquake. . . ." Civil Engineering Department Head **Nathan M. Newmark** has received the Washington Award from the Western Society of Engineers. An honor for engineers bestowed by fellow engineers, the award is conferred by six professional societies in Chicago.

The first man to earn a doctorate degree in Civil Engineering from the University of Illinois, Dean **Linton E. Grintner** of the Graduate School in the University of Florida, has been named acting executive vice-president there. He received his master's degree from the U of I in 1924, and his doctorate in 1926. He has been dean of the Graduate School at Florida for the past 17 years.

Edward F. Janzow, graduate student in the Nuclear Engineering Program, has received the distinction of being listed in the recently published 1969-70 edition of *Who's Who in the Midwest.* Janzow is a member of The American Society for Testing and Materials, the American Nuclear Society, as well as various honor societies. He entered the University in 1964 and currently is performing research in the desalination of sea water. ◆

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 8, APRIL 1969

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In the order listed, this issue contains articles on the following subjects:

BIOENGINEERING AT ILLINOIS
UNDERGRADUATE INSTRUCTION AWARDS
NOVEL USES OF PHOTOGRAMMETRY
ENGINEERING STARTING SALARIES
A BUILD CONFERENCE
REPRINTS OF ENGINEERING REPORTS

A PHYSICAL SCIENCE FOR PHYSICAL PROBLEMS

Bioengineering, a field that brings together engineering, biology, and medicine, shows many signs of becoming one of the most important areas of human endeavor in the not-far-distant future. In the years during and after World War I, chemistry and chemical engineering helped to revolutionize American industry; in the years following the second world war, physics and engineering brought new horizons to the life of our society. Many experts feel that in the next 20 to 25 years bioengineering will bring about even more significant changes.

The major figures in this newly emerging field, the life scientist and the engineer, have already begun to work closer together. Many biologists, physiologists, and physicians, whose work in the past was primarily descriptive, are using more quantitative methods, while many engineers have begun to think about the human condition in terms of the needs and problems of the individual. The engineers' traditional competence in the processing and control of information, energy, and materials, coupled with his abilities in the design and analysis of systems, can be a powerful tool in solving biological problems, including applications to medicine and the biological aspects of man and his environment.

The University of Illinois has a wide-ranging interest in bioengineering. One bioengineering group, bioacoustics, is studying the interaction between sonic and ultrasonic energy and various tissues. The Biological Computer Laboratory studies information processing and communication in living organisms. Biomechanics uses the engineer's physical and mathematical models, from which the life scientist can make deductions about biological systems.

Ergonomics applies the biological and engineering sciences to the adjustment of the human being to his work and his work environment. In conjunction with physiological studies, engineering research is underway on thermal regulation of biological systems. Areas of study such as health physics, veterinary medicine, waste management, and pollution control are increasingly demanding the skills of the engineer as well as the life scientist. As man becomes more aware of his effect on the environment and its effect on him, bioengineering will play an important role in discovering what man does in — and to — his world. Those interested in participating in this discovery at the University of Illinois should contact the Bioengineering Committee at 106 Engineering Hall, Urbana, for additional information. ◆

CONSTRUCTIVE INSTRUCTION

The University of Illinois, like any large corporate body, is concerned with making its product better. The product in this case is the well-educated student, and one of the methods of improvement is called Undergraduate Instructional Projects. These projects, which provide support for a faculty member while he works on them, are designed to improve the quality of undergraduate instruction.

Two professors from the College of Engineering have done such an excellent job that they have been given a special award for their contribution to undergraduate teaching. The awards, one thousand dollars each, were presented to Electrical Engineering Professor Thomas Murrell for instructional materials for courses in transistor circuits, and to Mechanical Engineering Professor Frank Morrison for the development of an undergraduate laboratory program in thermodynamics.

Both professors are convinced that their projects are not only instructive, but rewarding as well. ◆

R. C. Malhotra, Research Assistant in Civil Engineering, adjusts a stereometric camera of the type used in close-range precision photogrammetric processes being developed by Civil Engineering Professor H. M. Karara.

SEEING DOUBLE PAYS OFF

Photogrammetry has been used for a number of years as a fast and accurate method of aerial surveying and mapmaking. With the use of metric cameras, contour maps can be plotted in a fraction of the time it takes an earthbound surveyor. Now this technique is being used on the ground to make "contour maps" of previously uncharted areas.

In the Photogrammetry Laboratory, information on uses for close-range precision stereo photogrammetry is being gathered by Civil Engineering Professor H. M. Karara — and the uses are many, indeed. Photogrammetric measurement, since it is so perfectly suited for use with three-dimensional curvilinear forms, has applications with animals and even human beings. Beef cattle can be measured by photogrammetry and the information recorded on punched tape. A computer program can automatically calculate the weight of the various cuts of beef that the animal will produce. Effects of breeding and feed programs on meat production can be evaluated in this way, while allowing the animal to be kept for breeding purposes.

Measurement of the human body for medical purposes can be accomplished swiftly with stereometric cameras. Studies of an apparent correlation between a child's body shape and his mental condition have been made with the aid of the cameras (see *Outlook,* January, 1968).

Professor Karara, with the help of Professor L. E. Doyle of the Department of Mechanical Engineering, has been contacting industries to discuss development of possible uses of photogrammetry and perhaps uncover new applications. Photogrammetry is expected to be of use as a measuring tool in quality control inspections. It will be of particular interest to industries — such as the automobile industry — where production runs are short and tooling costs and set-up times are of major importance. Presently, new models must be planned about two years in advance, but a car design can be converted from clay model to finished body panels in one-third the time with the introduction of photogrammetric equipment. Instead of making tedious and time-consuming measurements of the clay model and using the measurements to make patterns for the dies, a stereo picture is taken. With the use of a photogrammetric plotting instrument and digital recorder, the information from this picture is transferred to a punched tape. The body dies are produced on tape-controlled equipment.

The stereometric process is useful in the production of any complex shape which is hard to define and reproduce: for airplanes, ships, and farm equipment. It has also been used to produce, with exact precision, windows for spacecraft. The unusual but very important contours of these windows must conform to strict specifications.

Farm equipment manufacturers have also used the photogrammetric method to produce patterns for special plows. Different angles are required for the different consistencies of soil in various parts of the world, and now each piece of equipment can be reproduced from a single model and distributed in the areas where it is of maximum efficiency. A farmer in South America was unable to describe exactly what he wanted. So he took his hammer and beat his plow into the shape he needed. A manufacturer took stereo photographs of the plow and reproduced it on a mass scale.

Architectural photogrammetry of buildings provides an easy method of obtaining a complete building plan when blueprints are not available. Historical monuments can be recorded in this way; the graphical plotting of these photographs need not be done unless the building is later damaged and must be repaired or rebuilt. Reproductions may be made from photographs. When the Nubian Temple at Abu Simbel was to be submerged by the waters of the Nile River, it was dismantled and moved to higher ground. But first it was photographed in stereo and carefully plotted to ensure that it would be reassembled exactly as it had stood for thousands of years.

The applications of stereometric precision photography seem to stretch to the horizon, and undoubtedly there are countless more uses yet to be thought of and tried.

With all the new practical ideas that are being discovered, many of the louder sounds of booming industry will soon depend on the quiet click of the shutter. ◆

STARTING SALARIES STILL SALUBRIOUS

Beginning salaries for engineering graduates from the University of Illinois at Urbana-Champaign have increased $101 in two years, according to Mrs. Pauline V. Chapman, placement director for the College of Engineering. February graduates with bachelor's degrees in engineering averaged $815 a month in their first jobs after graduation, she said. In 1967, midyear graduates began at $714, and 10 years ago, in 1959, the salary average was $505.

Her report on 302 midyear graduates of 1969 shows 63 per cent going immediately to jobs, as compared to 57 per cent last year and 50 per cent in 1967. In the same years, the number going on to graduate study dropped from 31 per cent in 1967 to 26 per cent last year, and to 16 per cent this year. The percentage going to military service has varied only slightly, from 7 per cent in 1967 to 6 per cent last year, and back to 7½ per cent for this February's graduates.

Aeronautical engineers beginning at $829 a month topped the list in average salaries for 1969 February graduates, with electrical and mechanical engineers a close second at $824, ceramic engineers $823, and metallurgical engineers $821. ◆

EDUCATION, TECHNOLOGY, AND THE DEMANDS OF SOCIETY

Many critics of the modern scene have raised questions about the relationships among education, technology, and the demands of society. While it may be that no two of them can concur on what the relationships should be, most of them agree that these three major forces are somewhat out of harmony. Concerned engineering educators see the question this way: what fundamental changes must be made in educational programs to produce engineers who are fitted, both temperamentally and professionally, to deal with our complex social problems, and also to help the members of the public better understand the technological society in which they live?

Late in April a group of engineering educators will meet in Colorado with representatives of the humanities, the social sciences, the business world, and government agencies to discuss this question. The conference will be conducted cooperatively by the University of Colorado and the University of Illinois under the sponsorship of the Kettering Foundation. Its result, a final report of conference conclusions and recommendations, will be described in these pages when it becomes available. ◆

A concrete reactor vessel being tested at the U of I Civil Engineering Department's Structural Research Laboratory explodes and sends debris flying into the air. The prestressed vessels are tested to failure as a part of a research project being carried out by professors Mete Sozen and Stanley Paul.

FROM A MILLION BELCHING CHIMNEYS

Air pollution is often a literally burning question these days, as state governments and local industries hurry to comply with the newly enacted federal regulations. But it was not always so. In 1948, when Professor H. F. Johnstone began work on the basic properties of aerosols — which often became toxic when discharged from factories — few people or officials were really interested. Until 1962, the professor and his research team at the University of Illinois Department of Chemical Engineering studied the behavior of these aerosols and fought battles as far away as Los Angeles to awaken the nation to its danger from air pollution.

Much of the report literature the project generated during these years is completely out of print, though the University still receives requests for it. One of the earliest reports, "Dynamics of Free Turbulence," by Thomas Baron, 1948, has been reprinted, and is available from the Engineering Documents Center, 208 Engineering Hall, University of Illinois, Urbana, for $2.00 per copy.

But all of the material is highly technical, dealing specifically with items like "The Velocity Field in an Isothermal Free Jet" and "Atomization of Liquid Jets and Droplets" and is liberally interlaced with formulae and graphs. And it *is* old. Therefore, a list of the thirty-four reports on file has been compiled, citing Xerox costs for each. The Documents Center will send the list to interested requestors, and will provide requestors Xerox copies of any of the reports listed. ◆

PEOPLE AND PLACES

Thirty high school teachers will attend an engineering institute, *The Man-Made World,* at the Urbana-Champaign campus of the University of Illinois, June 30 through August 8. A National Science Foundation grant supports the project of the Computer-based Education Research Laboratory. Professor **Donald Bitzer,** director, and **Dominic O. Skaperdas,** associate director, will be in charge.

On the occasion of his eightieth birthday, the *Journal of the American Chemical Society* honored Professor Emeritus **Roger Adams,** of the Department of Chemistry and Chemical Engineering, with a special editorial tribute in its January issue. The four-page article was written by Professor Nelson J. Leonard, of the Chemistry Department and the Center for Advanced Study.

The American Society of Agricultural Engineers has awarded first place honors to two staff members of the Department of Agricultural Engineering for their entries in the Society's annual extension exhibits competition. Professor **A. J. Muehling** was cited for both a slide production and a publication on confinements systems for swine. Professor **Donnell Hunt** was honored for an instructive display on machinery system selection.

Continuing a program started in 1961, the Department of General Engineering will offer its ninth Summer Institute in Engineering Technology for Junior College and Technical Institute Teachers July 16 through August 9. A National Science Foundation grant brings to a half-million dollars the total of NSF funds which have brought more than three-hundred teachers to Illinois from every state. The U of I is the only institution to offer the summer institutes every year. Professor **Jerry S. Dobrovolny,** head of the department, will direct the summer program.

Vice-Chancellor **Herbert E. Carter,** former head of the Department of Chemistry and Chemical Engineering, has received the 1968 Kenneth A. Spencer Award for Research in Biochemistry. The award, presented by the Kansas City Section of the American Chemical Society, recognizes outstanding achievement in agricultural chemistry. Vice-Chancellor Carter is also serving on the Long Range Planning Committee of the National Science Foundation. The committee is studying the future goals and roles of the NSF.

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 9, MAY 1969

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In the order listed, this issue contains articles on the following subjects:

A CONFERENCE ON ENGINEERING EDUCATION
ION PROPULSION
TEACHER EVALUATION
STRUCTURAL CONFERENCE PROCEEDINGS

SHOULDER TO SHOULDER TO BOULDER

Mountains, a degree of hopeful pessimism, and conversations about the relevance of higher education to the needs of society were the ingredients of a conference held April 23, 24, and 25 at Estes Park, near Boulder, Colorado. More than one hundred people — representatives of industry, the foundations, and government, plus students and faculty members from various educational institutions — met to discuss "Education, Technology, and the Demands of Society."

The Conference was the last major event of a five-year University of Colorado–University of Illinois program sponsored by the Commission on Engineering Education with funds from the Kettering Foundation. While previous activities of the program had been dedicated to improving engineering education, this conference was designed to foster discussions on the broader issues that face all of higher education. As the conference title suggests, the fundamental question was whether modern higher education is as relevant to the needs of society as it should be, and how it might be made more relevant in the future.

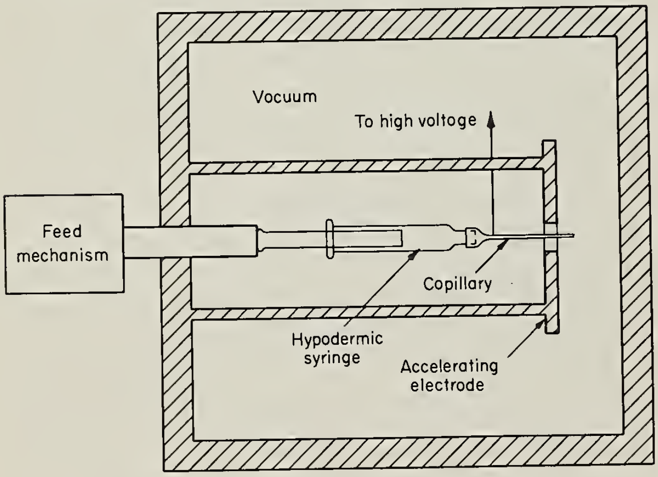
A large proportion of the attendees seemed to feel that there are many problems in urgent need of solution facing both higher education and society. They generally concurred that the major role of the universities is not so much to participate in finding these solutions directly as to learn how to produce graduates adequately prepared and motivated to help deal with them. There was some consensus that this requires a liberalizing of professional education; closer relationships between the physical, social, and life sciences, and the humanities; educational philosophies designed to produce graduates who might help to provide new or different directions to national priorities; and a recognition of the fact that students have earned and deserve a major role in the formulation of their own educational programs.

Engineers and engineering received an especially hard look at the conference. One oft-heard statement was that engineering faculty members do not possess a sufficient understanding of social problems. There was considerable agreement that information about the social consequences of technology must be included in the core courses of engineering education, and that design courses can be used to demonstrate technology's social impact. The conferees agreed that the engineer of the future must "understand and cope with conflicting values, social urgencies, economic complexities, and political processes. He must understand, at least interpretatively, the insights of the humanities and the methods of the social sciences." They also agreed that such preparation could not begin too soon. *Tempus fugit.*

Some of the overall conclusions of the conference were that current educational programs need much more flexibility; student advising systems need strong improvements; tenure, as it now exists, should be reexamined and reevaluated; the universities should establish more experimental pilot programs in all levels and areas of education; and that new university hierarchies should be considered, including such possibilities as structures that would permit and foster better relations with other social institutions and new structures that would allow departures from the discipline-oriented traditions that currently exist in academe.

The students, who were in attendance as full-fledged participants, submitted an independent tentative report that reiterated many of the recommendations made by their elders and added some new ones. Their report commented upon the necessity of acting quickly, the proper role of the student in the decision-making processes of the university, and the need for more flexibility in educational programs. In addition, it called for research on social problems, greater interaction between engineering and other disciplines, and the establishment of continuing symposia on society and technology.

It is difficult to gauge the success of a conference, especially before all the results are in. For anyone who would like to try, a proceedings will be published after all the notes, recommendations, and dissenting opinions have been sorted out. Its price will be nominal, and its birth and availability will be announced in these pages — unless we find a consensus that engineering college newsletters are a waste of time and money. ◆



A thin beam of particles from a capillary tube (above) may one day be used to power space flight. Liquid metal at the tip of the capillary (below) forms the beam, which is too small to be seen. Electrostatic propulsion is being studied at the U of I Charged Particle Research Laboratory.

A REACTIONARY PROPOSAL

One of Newton's laws, which have never been overturned in a higher court, states that for every action there is an opposite and equal reaction. Chemical rockets, such as the ones used in the Apollo program to land a man on the moon, are based on this principle. A burning fuel creates expanding gases which are forced out one end of the rocket (the action); the rocket moves in the opposite direction (the reaction). Although only 20 per cent efficient, this is an effective way of boosting heavy payloads into earth orbit.

For longer trips, say to the nearby planets, a more efficient method of propulsion is needed. One possible technique is electrostatic propulsion. A charged particle is accelerated by a high voltage (the action) and drives the vehicle in the opposite direction (the reaction). Electrostatic propulsion works quite nicely in the vacuum of outer space and can carry much more payload per pound than an equivalent chemical rocket since electrostatic propulsion can be nearly 100 per cent efficient.

There are some problems though. In order to work efficiently, the particles must have a uniform charge-to-mass ratio. The particles could be a single molecule with the charge of one electron, for example, or have the mass of a thousand molecules with the charge of a single electron, provided they all had the same charge-to-mass ratio. Another requirement is that the particles must be very easy to produce. If a minimum amount of energy is required to produce a particle, then there is more energy available to produce thrust. Finally, since the particles are small and light, they must be accelerated to very high velocities if they are to produce a measurable thrust.

Two methods of electrostatic propulsion have been studied at the Charged Particle Research Laboratory of the University of Illinois. The first used ions, single molecules with a charge of one or two electrons, to provide the thrust. But ion formation requires considerable energy, leaving less energy to accelerate them for thrust. The second method formed heavier particles composed of thousands of molecules. These were easy to form, but it was difficult to obtain particles with a uniform charge-to-mass ratio.

Donald Swatik, a graduate student in the Laboratory, has begun to combine the best of both techniques in hope of producing ionic particles with uniform charge-to-mass ratios, without using large amounts of energy to form them. Using an electrohydrodynamic technique, mercifully referred to as EHD, he has found that he can do just that.

His scheme begins with a working metal — an alloy of gallium and indium — which is in the liquid state. It is forced from a common hypodermic syringe into a capillary tube. The tube protrudes through a hole in a large, flat accelerating electrode. When the voltage between the electrode and the liquid in the capillary is high enough, a thin beam of particles is formed at the tip of the capillary. This phenomenon, known as field evaporation, not only produces particles with the proper charge, but also forms them into a small beam which has a high velocity. By forming the particles and accelerating them at the same time, there is little energy wasted in their formation, and the particles can produce maximum thrust.

Although Swatik's model produces only 50-millionths of a pound of thrust, it was a great improvement over earlier attempts which could produce a thrust of only one- or two-millionths of a pound. This rather modest thrust could be multiplied if EHD thrustors were used in banks of hundreds, or perhaps thousands.

The understanding gained through Swatik's research shows that EHD thrustors have considerable promise for future space applications. It seems probable that he is one student who can count on future government support — even if the main thrust of his research is clearly reactionary. ◆

WILL TEACHERS FLUNK OUT IN THE FUTURE?

While there has been increasing talk in higher education about de-emphasizing grades for students, much consideration has been given at the same time to the effectiveness of grading the faculty member's performance in the classroom. A recent student-published course guide on the Urbana campus that evaluated teachers in various courses has proved to be quite popular with the students. But in spite of the fact that this first effort was a good job and offered some quantitative assessments of faculty performance, it lacked a comprehensive and scientific background.

A more organized and statistically valid method of conducting instructor evaluations is being studied in the General Engineering Department. This faculty evaluation system has been operated for several years by T. C. Hartley, Associate Professor of General Engineering, who has a degree in psychology. Professor Hartley collects data from the student at the end of each year by having him complete an instructor rating form for each class he attended. The form rates the instructor on twelve characteristics on a five-point scale. These characteristics range from "enthusiasm in teaching" to "ability to explain difficult material" and conclude with an over-all rating of the instructor's effectiveness as a teacher.

The results in each section are computer processed and presented to the instructor in the form of a mean rating for each of his attributes. This allows him to see his own strengths and weaknesses. Same-course or course group tabulations afford a profile of item rankings which allows him to compare his own rating with those of his colleagues. This gives the teacher diagnostic feedback about his strong points and specific information about which areas he might improve. The ranking with his peers gives him motivation to improve or continue good performance. For the administrator, the ratings provide a way to assess the range of student evaluations received by staff on various teacher functions. It also helps to calibrate the teaching abilities of graduate students who wish to join the faculty.

Professor Hartley stresses that although there are no absolute standards against which the student opinions can be measured, the comparative data prove to be useful. In addition, the results of the study seem to agree with some commonly observed teaching phenomena. For example, an instructor who teaches the same class twice in one day will do a better job the second time. He also does a better job in a course he likes. Desirable and undesirable teaching, grading, and personal habits are readily observed from the rankings, and the students seem to appraise their teachers seriously and fairly.

Although there is no official college-wide student evaluation, Professor Hartley feels that it would be advantageous to both students and faculty members if such programs were developed further. He would at least like to see evaluations widely made for the instructor's own use. Profiles derived from these evaluations could provide administrators with much useful information related to the quality of instruction in the classroom. Professor Hartley may be right: almost everyone who thinks about grading, either positively or negatively, agrees that its main purpose should be to help the man help himself. ◆

BETTER LATE THAN NEVER

Working from the theme of "Structural Engineering in Modern Building Design," the 1966 Illinois Structural Engineering Conference explored nontechnical aspects of modern structural engineering practice, as well as the technical advances in structural analysis and design. The Conference was conducted by the University of Illinois with the close cooperation of the Structural Functional Section of the Illinois Society of Professional Engineers.

The Proceedings of the Conference cover topics ranging from wind loads of tall buildings to the engineer-architect relationship. Copies of the 213-page proceedings may be obtained from the Engineering Publications Office at a price of $5.00. ◆

PEOPLE AND PLACES

The College of Engineering Alumni Honor Award for Distinguished Service in Engineering is given annually to alumni or former staff members who have distinguished themselves by outstanding leadership in planning and direction of engineering work, by fostering professional development of young engineers, or by their contributions to knowledge in the field of engineering. The College will honor seven alumni at its Annual Awards Convocation this year. They are: **W. L. Collins,** soon to be named Executive Secretary Emeritus of the American Society for Engineering Education; **Garrett C. Covington, Jr.,** Vice-President, General Engineering, McDonnell Company; **C. E. De Leuw,** Chairman of the Board, De Leuw, Cather and Company; and **W. B. Greene,** retired Chairman of the Board, Barber-Greene Company. Also honored are **R. J. Greenshields,** Director of Research, Shell Oil Company; **Ernest Ingold,** retired Head of Ernest Ingold Investment Company; and **G. R. Irwin,** Boeing University Professor, Lehigh University.

Three Alumni of the College of Engineering in the University of Illinois are among forty-four persons just elected to the National Academy of Engineering. They are **Robert B. Bird,** Burgess Distinguished Professor of Chemical Engineering in the University of Wisconsin at Madison; **George W. Kessler,** Vice-President for Engineering, Babcock and Wilcox Company; and **Frank E. Richart, Jr.,** Professor and Chairman of the Department of Civil Engineering in the University of Michigan at Ann Arbor. Election to the National Academy of Engineering is the highest professional distinction which can be conferred upon an American engineer. Nine faculty members of the College of Engineering at the University of Illinois are members. ◆

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 10, NO. 10, JUNE 1969

In the order listed, this issue contains articles on the following subjects:

A NEW DEAN AT CHICAGO CIRCLE
A CENTRALIZED LABORATORY
DOG AND CAT TOILETS
A PUBLICATIONS ORDER FORM

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CIRCLE GETS NEW DEAN

The University of Illinois Board of Trustees has approved the appointment of George Bugliarello as Dean of the College of Engineering on the Chicago Circle Campus, beginning September 1.

Professor Bugliarello holds a Doctor of Engineering in Hydraulic Engineering from the University of Padua, a Master of Science in Civil Engineering from the University of Minnesota, and a Doctor of Science from Massachusetts Institute of Technology. He has been an assistant to the Chair of Special Hydraulic Projects at the University of Padua, a research associate in the Hydrodynamics Laboratory at M.I.T., and a member of the Faculty at Carnegie-Mellon University since 1959. There he served as Professor of Biotechnology and Civil Engineering and was Chairman of the Biotechnology Program from 1966 until he came to Chicago Circle. ◆

TO EACH HIS OWN

Included in the problems that engineering education faces in continually updating its curricula is the one that many educators consider most difficult — keeping laboratory work not only current, but also relevant to the changing needs of modern technology. An associate professor of Mechanical Engineering at the University of Illinois has developed an intriguing new method for dealing with this problem.

Dr. A. M. Clausing is designing a unique kind of laboratory for studying the laws and processes of heat transfer. It consists of a number of separate experiment stations which give the appearance of workbenches with large metal cabinets. The cabinets contain electronic instruments and outlets for a number of utilities. Each station supplies the student with the equipment necessary for basic studies in heat transfer, fluid dynamics, and thermodynamics. All that is necessary is to make the proper connections to the particular apparatus which the student is testing. This is done by means of quick-connecting tubing and electrical cables. The devices which are to be tested are made as portable as possible so that one student can easily move any of them to his experiment station.

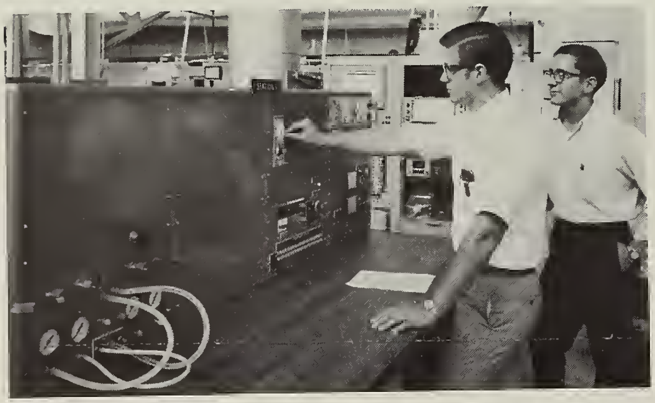
The nucleus of the laboratory is the data recording center which handles much of the busy work previously left to the student. Here temperatures, pressures, and other numerical data are recorded several ways. At the present time a student may receive his experimental data in tabular form as well as in continuous graphs. Future additions to the data recording center are expected to include a connection to one of the University's large digital computers or the incorporation of a small computer into the recording center itself. All of these facilities will be available to each of the experiment stations at the flip of a switch.

Safety devices are incorporated into every experiment station, including a "Panic Button" which cuts off all power to the individual station. The ease with which these stations can be operated adds to their safety, as well as making them suitable for use by students at many levels of study.

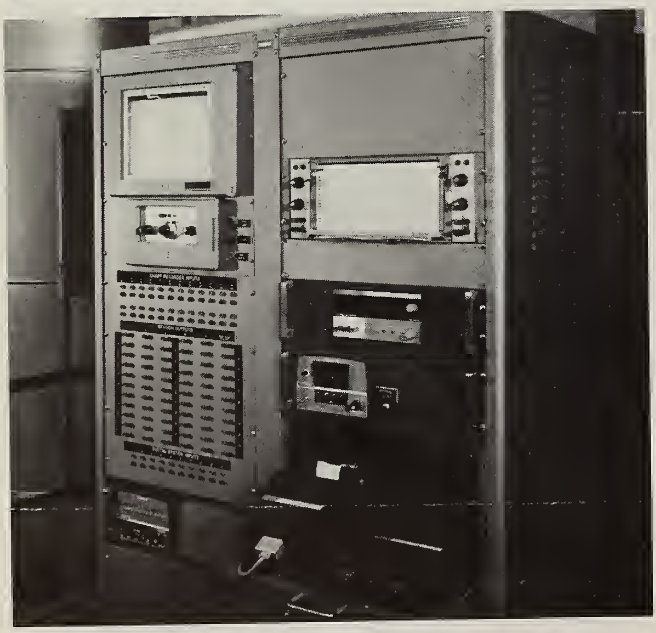
The cost of one workbench experiment station is approximately the same as the unit cost of commercially available "package" experiments designed to study a single process. The commercial units generally exclude the cost of instrumentation, which is an expensive part of any such apparatus. The workbench stations contain all of the equipment necessary for performing a wide variety of experiments, but are arranged in such a manner that a large number of students working in small groups can use the same central recording equipment. This centralization of expensive equipment substantially reduces the initial cost of the laboratory and promises the same advantage for future expansions.

Dr. Clausing has received financial grants from the National Science Foundation and the University of Illinois totaling $33,000 for the purchase of equipment.

These grants helped transform a significant educational innovation into reality. Instead of dropping out of lab courses, students will soon be plugging in and turning on. ◆



Graduate students Jim Shahan and Eric Jahnsan (above) examine the controls at an instrumentation station of the new Mechanical Engineering heat transfer laboratory. The data recording center (below) is capable of printing out numerical data in tabular form or in continuous graphs. It will record temperature, pressure, and other readings from several stations at the same time.



HOT AND BOTHERED ABOUT HEAT TRANSFER

While some forms of heat transfer are indeed more interesting than others, space exploration, nuclear power generation, and high-speed flight are engineering areas that require the ability to predict heat transfer rates with great precision and detail. In response to this growing interest, a one-week course entitled "Advanced Heat Transfer" was offered to the public during April of 1967. Lecture notes were preprinted and distributed to the participants. These notes became so popular that the supply was rapidly exhausted, although requests for them continued to pour in. Because of this demand, the University of Illinois Press, in cooperation with the Engineering Publications Office, has published a book which presents the revised course lectures, *Advanced Heat Transfer.* This 459-page book presents the physical concepts and governing equations for both convective and radiative heat transfer. It includes discussions of computer applications to heat transfer and a number of specific problems in heat transfer, ranging from nucleate pool boiling to bioengineering.

Advanced Heat Transfer should not only be useful to the heat transfer engineer, but may also be used as a subsidiary text for advanced courses in the subject. It is available from the University of Illinois Press, Urbana, Illinois, at a price of $12.50. ◆

ONLY IN AMERICA

One of the less pleasing aspects of apartment living is the daily ritual of walking the dog. While Fido may enjoy an early morning stroll, the apartment dweller usually finds that inconvenience offsets any therapeutic value in a brisk walk. With this in mind, two University of Illinois undergraduate general engineering students, Jay Bogg and Doug Medley, undertook a unique project for their design course — a dog-cat toilet for permanent installation in family bathrooms.

The commode is about 18 by 30 inches, and 6 inches high. An electrical trip mechanism flushes it automatically after the pet steps out. A portable unit has also been planned for existing buildings which haven't incorporated the invention into their construction plans, or for pets on vacation. In case a family moves into a pet-plumbed apartment without a pet, the students plan to provide a kit to turn the toilet into a fish bowl, lily pond, or fountain. The mechanism can even be adjusted to provide continual showers of water for special effect.

There was some question as to what the pets would think of the whole idea. Dr. Lloyd Boley, department head in Veterinary Clinical Medicine at the U of I, has foreseen little difficulty in training animals to use the pet toilet; Siamese cats are often known to use standard toilets. Dr. Boley has offered to give the invention a "test run" at the animal clinic.

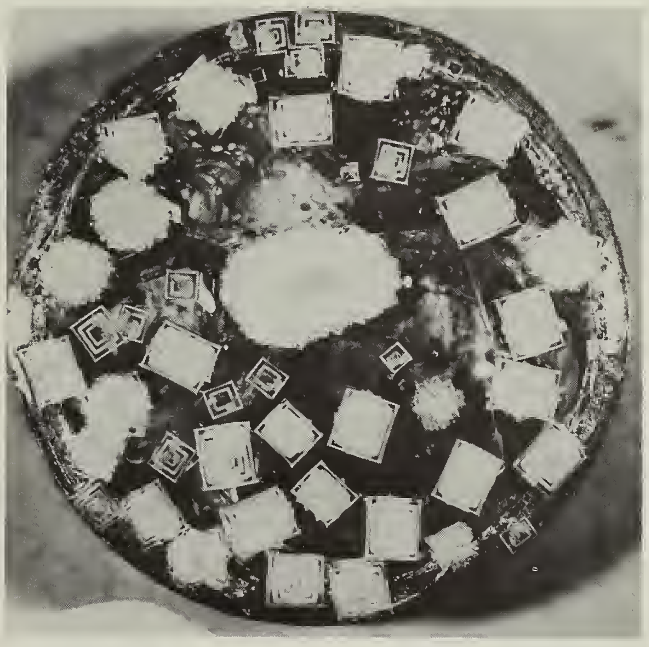
Boggs and Medley hope to market the finished version of their device in several colors, perhaps with miniature fire-hydrant attachments for the more light-hearted dog owners. What started out as a joke ended up making sense — at least one manufacturer of plumbing fixtures has expressed a commercial interest in the project. After completion of patent applications, Boggs and Medley may incorporate to market their product. One hopes they will have the restraint not to use their initials in the company's name. ◆

WATER, WATER EVERYWHERE

The rhyme of the ancient mariner may well become the chant of the modern urbanite if the problem of obtaining clean water for the American city isn't solved. Municipal water was once obtained by tapping the nearest stream; now, however, there are almost no streams which can be used as sources of drinking water without treatment of some kind. The Eleventh Sanitary Engineering Conference, held at the University of Illinois last February, examined the quality standards of drinking or "ideal" water and how the characteristics of the raw water influence the cost and treatment processes required to achieve this ideal water. The Conference Proceedings, *Influence of Raw Water Characteristics on Treatment,* will be published on June 2, 1969. The proceedings can be ordered from the Engineering Publications Office at $4.50 per copy. ◆

TRYING HARDER PAYS OFF

The University of Illinois at Urbana-Champaign leads the nation in engineering college research, according to a survey by the American Society for Engineering Education. The society's journal, *Engineering Education,* reports the College of Engineering in the U. of I. has 597 separately budgeted research projects, with expenditures totaling $15,590,060 for the year. Next are Massachusetts Institute of Technology, $12,444,000 for an unspecified number of projects; Stanford University, $12,421,223 for 593 projects; and the University of Michigan, $11,160,000 for 544 projects. The University of Illinois is listed as third in engineering-related research by university units outside the engineering college. In engineering research at the University of Illinois, the greatest number of projects, 144, are in civil engineering, and the largest expenditures, $2,526,000, in electrical engineering. ◆



What appears to be an abstract painting is really a collection of lead diborate crystals grown on a surface of molten glass. U of I Professor C. G. Bergeron is studying the interfacial energy between the glass and the crystals in order to determine the characteristics of the crystal's growth.

PEOPLE AND PLACES

Two chemists and a physicist from the University of Illinois are among 135 leaders of education, the professions, business, and international affairs elected to membership in the American Academy of Arts and Sciences at its 189th annual meeting in Boston. **Herbert S. Gutowsky,** Head of the Department of Chemistry and Chemical Engineering; **Gregorio Weber,** Professor of Biochemistry, and **Charles P. Slichter,** Professor of Physics and member of the Center for Advanced Study, are among 106 Americans elected fellows of the Academy.

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Rodney W. Rieger has been selected for the 1969 exchange scholarship between the University of Illinois College of Engineering and the Technical University at Munich, Germany. Although Rieger has studied German for five years, he will begin his stay in Germany with two months in the Goethe Language Institute. He will attend the Technical Institute from November to July.

Civil Engineering Professor **L. R. Shaffer** has been appointed assistant director of the Army Corps of Engineers Construction Engineering Research Laboratory being established at Urbana-Champaign. The Laboratory will apply systems engineering approaches to the study of complex defense construction problems. Professor Shaffer has been in charge of the U of I academic program in construction engineering for several years.

The 1969 Dural Research Prize for outstanding undergraduate research in civil engineering has been won by **Bruce R. Ellingwood.** His research, completed as a junior in the U of I Department of Civil Engineering, was an investigation of probabilistic factors in the strengths of columns.

Professor **Chester P. Siess**, Department of Civil Engineering, has received an honorary membership in the American Concrete Institute for "outstanding service to the institute and professional contribution to knowledge of concrete." Professor Siess, a member of the Institute since 1938 and a former director, is among approximately fifty persons who have received the honor. Eleven have been associated with the University of Illinois.

An honorary degree of Doctor of Laws was conferred June 1 on Professor **Nathan M. Newmark,** Head of the U of I Department of Civil Engineering, by the University of Notre Dame at its 124th commencement. The University cited Newmark as "an inspired and inspiring engineering educator who has brought forth a distinguished intellectual progeny in almost forty years of continuous service to the University of Illinois and to "the engineering profession." ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

RESEARCH

EDUCATION

PUBLIC SERVICE

UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 11, NO. 1, SEPTEMBER 1969

OCT -1 1969

In the order listed, this issue contains articles on the following subjects:

ORTHOPEDIC CERAMICS
INTERNATIONAL SEMINAR FOR HYDROLOGY PROFESSORS
A NEW RADIOTELESCOPE
FUNDS FOR LINAC
TRIGA REACTOR POWER INCREASE

NO BONES ABOUT IT

One of the major problems with biological transplants is the scarcity of specimens that will not be rejected by the receiving body. This difficulty can be largely overcome by using prosthetic materials — synthetic substitutes — for anatomical parts. Efforts in this area have been particularly successful in creating viable bone substitutes from ceramic materials. While such substances as alumina have been accepted by living organisms and have proven strong enough to handle the physical loads, very little is known about the long-term effects of a physiological environment on the implanted material.

Some studies at the University of Illinois already have been undertaken to observe the deterioration of synthetic bone materials in dogs over periods of several weeks. The most remarkable change noted has been a pronounced decrease in the strength of the material due to a stress-enhanced corrosion of the specimen by the biochemical environment. In order to further examine this and other effects, Dr. Sherman D. Brown, Associate Professor of Ceramic Engineering, as principal investigator for research on orthopedic ceramics to the National Institute of Health, has submitted a proposal. The research would develop the apparatus for quantitative, in-vitro testing of prosthetic materials for stress-enhanced corrosion, relate the experimental information to the microstructural properties of the material such as porosity and surface condition, and use this information and data on the rate of matter interchanging between the implant specimens and living tissues to develop sound designs for prosthetics made from presently available materials. ◆

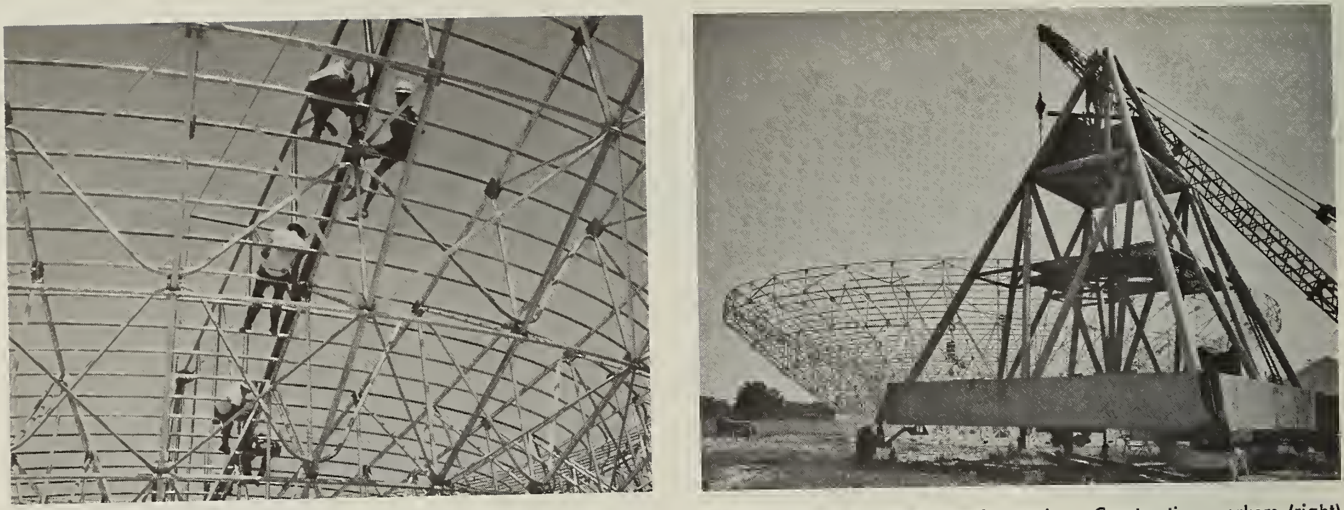
WATER ON THE BRAIN

In the Midwest, where the rain most often just disappears into the ground, the characteristics of water runoff are strictly of interest to academicians in the field of hydrology. But in California, for example, where a rainstorm may put a front lawn in front of the wrong house, water runoff phenomena take on a much more serious appearance. In either case, the study of what exactly happens is the business of the hydrologists who met at the University of Illinois from July 13 to July 25 for the first International Seminar for Hydrology Professors.

The director of the seminar was Professor Ven Te Chow, of the Department of Civil Engineering, whose expertise in the field has been recognized by the United Nations. Representatives from nineteen countries attended to hear the presentation of more than fifty papers on subjects in hydrology. Discussions were held on topics ranging from the teaching of hydrology and international hydrologic programs to theoretical hydrology and the scientific methods that have been developed for computer-aided modeling of hydrologic systems. The seminar, sponsored by the U.S. National Committee for the International Hydrological Decade, the NSF, UNESCO, and the Universities Council on Water Resources, among others, is an activity initiated through cooperation in the International Hydrological Decade. ◆

OUT OF TOWN ON A RAIL

A new radiotelescope for the University of Illinois is under construction near the site of the present radio astronomy facility outside the city limits of Danville, Illinois. Unlike the large existing antenna, which covers an area as big as two football fields and is built into a dry riverbed, the new one is a steerable, motor-driven parabolic dish. The dish, made of construction steel and aluminum and covered with a thin wire mesh, is 120 feet in diameter. It was constructed entirely under the direction of University of Illinois staff members by students and nonacademic employees working part-time.



The new parabolic radiotelescope (left), under construction at the Vermilion River Observatory of the University of Illinois, can be seen behind the 65-foot tower being readied to support it. The man atop the tower is adjusting the mounting angle of the antenna to match the polaris angle of the earth's rotation. Construction workers (right) are assembling the framework of the 120-foot-diameter dish forming the antenna.

The antenna project is conducted under the direction of Professor G. W. Swenson of the Electrical Engineering Department. Funds for the project are being provided by the National Science Foundation, while many of the machine tools used during the construction were furnished by the Department of the Navy. A considerable amount of the work of the construction crew had to be devoted to making the machine tools operational. Some of the tools that are now being used had been classified as unserviceable before their donation to the University.

Because of a lack of money from the National Science Foundation, the project, which originally consisted of three such antennas on a monorail track, had to be cut back to the single antenna being built. However, since the antenna and construction facilities were built entirely by University employees, the cost has been much lower than even the NSF expected to pay for such an instrument. ◆

A HAND FOR THE FIVE DIGITS

Starting salaries for engineering students have been increasing steadily over the past several years, but the graduates in June 1969 were the first to receive annual salaries which averaged over $10,000. This presents an increase of 61 percent over the decade.

The highest-paid graduate is an electrical engineer who will start earning $945 a month, and the average monthly salaries of graduates in the four fields — mechanical engineering, electrical engineering, engineering physics, and ceramic engineering — exceeded the overall monthly average of $834. Now if only there were some other reason for entering the field. ◆

FASTER THAN A SPEEDING BULLET

That's a continuous beam of electrons with energies in the neighborhood of 30 million electron-volts. That's also the expected output of the new LINAC (linear accelerator) being completed at the University of Illinois. Not only is this LINAC the first machine capable of producing a continuous, high-energy beam, it is the first machine to use a cryogenic (supercold) environment for its accelerating equipment. Operation of the machine at temperatures around minus 456 degrees Fahrenheit allows production of the continuous beam and opens many new opportunities for high-energy nuclear research.

Professors James Allen, Peter Axel, and A. O. Hanson of the Department of Physics are in charge of the project. Funds for the construction and initial operation of the LINAC were provided by the National Science Foundation. The latest grant of $175,000 to allow completion is part of $500,000 from the NSF for the machine. In the future, the superconducting LINAC is planned to be incorporated in a system with a racetrack microtron which sends electrons through the accelerator up to twenty times, achieving energies of 600 million electron-volts. Pretty soon they ought to find out what they're shooting at. ◆

COMPUTER EMERITUS

The University of Illinois Department of Computer Science has retired its IBM 7094 computer. The computer, formerly the workhorse for the instructional and research data processing of the College of Engineering, has been made unavailable for general use. Its work load has been transferred to the new IBM Systems 360/75 that was put into operation during the last academic year. The changeover leaves the System 360 as the only computer available to handle course work in programming and computer science as well as continuing research and course work in other departments.

The 7094 system, in operation since 1962 as one of several computers used by the College of Engineering, will not be replaced with another computer available for general use. Until September 1970, when both the extent of its use and the need for computer time are reevaluated, the 7094 and its two IBM 1401 support computers will serve only the high-energy physics research group in the Department of Physics. An existing time-sharing facility with the Coordinated Science Laboratory will be maintained, but the FASTRAN language — a modified FORTRAN II compiler — and all the other features that have warmed the hearts of senior citizens on the engineering campus are probably gone forever. ◆

WHAT?

A symposium on the "Cavitation State of Knowledge," sponsored by the Cavitation Committee of the American Society of Mechanical Engineers, was presented at the American Society of Mechanical Engineers Fluids Engineering and Applied Mechanics Conference at Northwestern University on June 16 and 17. The objectives of the symposium were to present the state of knowledge on cavitation in an understandable form and to note and collect indications of where there is a lack of understanding in the field.

Professor J. M. Robertson, of the Department of Theoretical and Applied Mechanics at the University of Illinois, is chairman of the Cavitation Committee of the ASME Fluids Engineering Division. Along with Professor G. F. Wislicenus, of Pennsylvania State University, he was instrumental in organizing the symposium.

According to Professor Robertson, this was "the first symposium of its kind offered by the ASME. . . . This time, invited experts in the particular field of cavitation have been assigned topics on which to write papers." Besides noted experts from the United States, some of the foreign contributions to the field were discussed by J. Raabe, of the University of Munich. He spoke on "Cavitation Effects in Turbomachinery — European Experiences." It is sincerely hoped that the symposium was successful in elucidating the subject. ◆

BIGGA

In 1960, the TRIGA nuclear reactor at the University of Illinois could produce only 100 kilowatts (100,000 watts) of continuous power output. By 1963, the steady power output had been increased to 250 kilowatts, and the reactor power could be pulsed to 1,000,000 kilowatts. Now, after the completion of modification begun in 1966, the reactor is producing 1,500 kilowatts of continuous power and pulses of power up to 7,000 megawatts (7,000,000 kilowatts). The new capabilities of the machine will allow generation of twice that amount of continuous power, and power pulses may be raised to 10,000 megawatts.

The TRIGA (Training, Research, Isotope-production, General Atomic) reactor has greater capabilities than any other university reactor, and its performance is equalled by only one other similar reactor in the country. To create its new performance, major modifications included replacement of aluminum-clad fuel elements by elements clad with stainless steel, remodeling of the interior of the reactor to handle the new fuel, construction of a new cooling system, and installation of a new control console. The $400,000 cost to complete the modifications was shared by the Atomic Energy Commission, the National Science Foundation, and the University.

The University had no trouble finding a taker for the used reactor parts removed for the remodeling. Through a cooperative program with Michigan State University, that school received the parts for the construction of a reactor, which is now operational. Soon they can start their own program of modifications until the day when their reactor also has the capability to continuously illuminate fifteen thousand 100-watt lightbulbs. ◆

PEOPLE AND PLACES

In February 1969, during the one hundred and first year of engineering education at the University of Illinois, **William J. Elsesser** became the twenty-five thousandth person graduated from the College of Engineering. He is following his undergraduate studies in mechanical engineering with work toward a master's degree at the Chrysler Institute.

A member of the TRIGA nuclear reactor staff, Orville Whipple, is shown making modifications to the core. After completion of the remodeling, the new reactor system was fueled for operation in the summer of 1969.

Professor **William A. Oliver,** of the Department of Civil Engineering, has been elected to a three-year term as director of the American Society for Testing and Materials. He has, since 1937, been a member of the society, which is the largest developer in the United States of nationally used standards for products and materials.

Dean Emeritus of the College of Engineering, **William L. Everitt,** has received the 1969 National Society of Professional Engineers Award for outstanding service to the engineering profession. He is the eighteenth recipient of the annual award presented for "leadership in engineering as exemplified by his development of young engineers, his contributions to engineering organizations, and his standards of professional conduct in all his endeavors."

Professor **Richard S. Engelbrecht,** of the Department of Civil Engineering, has begun serving as the forty-first president of the Central States Water Pollution Control Association. The purpose of the association, of which he was vice-president during the previous year, is to advance the knowledge of waste treatment facilities through the exchange of technical information and experience.

Professor **Edward C. Jordan,** head of the Department of Electrical Engineering, recently served as chairman of the United States delegation to the Sixteenth General Assembly of the International Union of Radio Science. Professors **Sidney A. Bowhill, Georges A. Deschamps, Chalmers F. Sechrist, George W. Swenson, Jr.,** and **James W. Warwick** of the University's engineering faculty also attended as part of the 185-man U.S. delegation. Professor Bowhill, who is editor of *Radio Science,* the journal of the International Union, served with Professor Jordan as a voting delegate.

Dead at the age of ninety-one is the inventor of modern sound film. Professor **Joseph Tykocinski-Tykociner,** on the faculty of the University of Illinois since 1921, demonstrated his invention in 1922, less than ten months after his arrival in Urbana. Professor Tykociner had been preoccupied with the idea of recording sound on film for many years, but lack of money and a place to do the necessary research, or perhaps a general lack of sympathy for the endeavor, prevented its earlier success.

After a long, losing battle to obtain further support for an invention in which the University had lost faith, and after failing to obtain support from other sources, Professor Tykociner gave up on the promotion of the idea. He continued his work at the University in other fields of electrical engineering until his retirement in 1946, after which he devoted all his time to the development of zetetics, a new interdisciplinary science. ◆

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ENGINEERING OUTLOOK

AT THE UNIVERSITY OF ILLINOIS IN URBANA

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 11, NO. 2 OCTOBER 1969

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In the order listed, this issue contains articles on the following subjects:

THE NEW LABORATORY FOR ATMOSPHERIC RESEARCH
ADMINISTRATIVE APPOINTMENTS IN THE COLLEGE
SEISMIC WEIGHING OF VEHICLES
CONFERENCE ANNOUNCEMENTS

AIR WATCHERS

The successful work that has been done elsewhere in the mathematical modeling of atmospheric conditions, the capabilities of the automatic data processing equipment at the University of Illinois, and the large amount of related research already on this campus have led the Graduate College to establish a new Laboratory for Atmospheric Research headed by Professor Yoshimitsu Ogura. The new Laboratory already has drafted a proposal to obtain funds for work on the numerical simulation of atmospheric motions.

Atmospheric modeling poses a number of serious problems, not the least of which is the impossibility of testing the models in a laboratory. In addition, any given weather condition is the result of an extremely complex set of interactions, and a model of these interactions is likely to consist of a set of nonlinear equations subject only to a computer solution. If working simulations can be achieved, however, they could have far-reaching effects on the fields of atmospheric study and weather prediction.

One example which Professor Ogura cited was the apparent dependence of the development of hurricanes on the temperature of the surface of the ocean. If a mathematical simulation of a hurricane weather system could be achieved, this dependence and the dependence on other atmospheric influences could be determined quickly by varying the parameters of the model.

The work of the Laboratory also will center around the study of what Professor Ogura calls "meso-scale effects." Such meso-scale effects include squall lines, hailstorms, and tornados. These effects can profoundly influence weather conditions, but very little is understood about their dynamics. Present weather monitoring systems use data taken over geographic intervals of several hundred miles. As a result, only large-scale atmospheric conditions are recorded accurately.

Professor Ogura also expects to study the dynamics of the upper atmosphere and the reasons for certain unexplained high-altitude weather conditions. Some examples of strange stratospheric behavior are the two-year cycle of equatorial prevailing winds from easterly to westerly and the fairly rapid changes in temperature which occur at higher latitudes.

A clearer understanding of such atmospheric phenomena could lead to improved weather prediction, and if means can be found to influence critical factors in the real systems, control of some weather conditions eventually may become a reality. ◆

HEADS CROWNED

Professor Ross J. Martin, Director of the Engineering Experiment Station, has been named to a new associate-deanship of the College of Engineering. In this position, he will be involved with the administration of graduate programs and research activities. Although responsibilities of somewhat greater scope are implicit with the appointment, they include all of the present functions of the Director of the Experiment Station. The new position permits a more direct involvement in the academic affairs of the College. The existing Office of the Associate Dean and Associate Dean Howard L. Wakeland will remain responsible for the administration of undergraduate affairs.

In Dean Wakeland's office, a new position of assistant dean has been created to give the engineering faculty a chance to get more involved and develop a better understanding of administrative activities. As a half-time appointment, the new deanship will be rotated every one or two years to involve each of the engineering departments. The half-time job allows the appointee to remain actively engaged in research and teaching and will prevent complete isolation of the Office from these endeavors. The need for more manpower had developed through the increased administrative responsibility of the Office for a new program of cooperation with pre-engineering programs at Illinois junior colleges.

The first person to occupy this post, Assistant Professor Blake E. Cherrington, of the Department of Electrical Engineering, feels that his participation in all of the activities of an assistant dean will allow him to give a fresh evaluation of the organization of the Office. He also indicated that a term of two years had been projected as adequate for a faculty member to become acquainted with the responsibilities. His term may be extended to two years if the first year does not provide him with a sufficient orientation. Professor Cherrington shares Dean Wakeland's opinion that direction of the Office should come from the faculty. The new dean will provide a new viewpoint and first-hand information from the faculty; both should give valuable guidance to the administration. ◆

NOT WITH A BANG, BUT WITH A RUMBLE

Professor Howard W. Knoebel and Senior Research Engineer Bill Kirkwood, of the Coordinated Science Laboratory, will soon be installing a test facility to check the feasibility of using seismic instrumentation to weigh moving vehicles. The installation, to be made on U.S. Highway 12 south of Fox Lake, Illinois, will record the signals from seismometers buried in the roadway. The data taken there will be used to determine the reliability of weight measurements and the best arrangement of the sensing devices.

Records of the initial measurements at the highway test facility will be returned to the University for computer analysis. The results should indicate the amount of computation necessary to determine vehicle weight. The appropriate automatic equipment may then be developed and installed. The test measurements also could show the effects of joints in the highway on the accuracy of the weighing, but securing this information will depend on the exact location of the site, which is not yet known.

The seismometer used to detect the moving vehicles is small enough to be buried in the hole left by the type of boring commonly used to determine highway thickness. Buried below the road surface, the instrument monitors the inertial motions of a weight suspended against gravity inside its case. Originally developed for oil exploration, it has to be used with an electronic equalizer network to correct for its nonuniform frequency response. With the equalizer, its signal accurately represents the motion of the earth and the case around the instrument's floating core. The signals also would be very much dependent on the amount of freezing and residual water under the roadway, but large highways are usually constructed on uniform load-bearing surfaces which are well drained.

Preliminary studies of signals obtained from trucks driven in University parking lots have yielded measurements with an accuracy of around 10 percent. While this is not accurate enough to eliminate mechanical scales to check truck overloads, it is sufficient to allow most vehicles to pass the weighing stations if their weights are not questionable. The tests also showed that if the roadbed material is fairly uniform, the placement pattern of the monitors becomes less important making the path of the passing vehicle less critical. Previous efforts to construct mechanical weighing devices into roadbeds proved unsuccessful because of maintenance problems.

The results of this research have already shown that keeping an ear to the ground can have its advantages. The only problem now may be to keep it there after a few trucks have gone by. ◆

WATER WORKS

Engineers, contractors, and planners in the water supply field are invited to attend a one-day conference on Water Resource Development Costs sponsored by the Illinois State Water Survey. The program will begin at 10:00 a.m. and will continue until 4:00 p.m. on Tuesday, October 21, in the Water Resources Building at 605 East Springfield Avenue, Chaimpaign, on the University of Illinois campus. The conference involves no fee and requires no advance registration.

Discussion will center on cost criteria developed by the State Water Survey for planning reservoirs, transmission lines, and water treatment facilities. Technical letters published by Survey engineers and dealing with these cost studies will be presented by the authors and will be available to conference participants. Participants also will be given the opportunity to ask questions and to discuss each letter following its presentation.

Requests for additional information and notifications of planned attendance should be directed to William C. Ackermann, Chief of the Illinois State Water Survey, Box 232, Urbana, Illinois 61801. ◆

BIGGER WATER WORKS

The Twelfth Sanitary Engineering Conference will be held in Urbana, Illinois, on February 11 and 12, 1970. The conference, entitled "Nitrate and Water Supply: Source and Control," is planned for engineers and scientists in private practice, government, or industry, and water works managers and operators. The Division of Sanitary Engineering of the Illinois Department of Public Health and the Civil Engineering Department of the University of Illinois are joint sponsors.

More information about this conference may be obtained from R. S. Engelbrecht, Professor of Sanitary Engineering, 3230 Civil Engineering Building, University of Illinois, Urbana, Illinois 61801, or from C. W. Klassen, Chief Sanitary Engineer, Department of Public Health, Springfield, Illinois 62706. ◆

CHEAP TALKS

The Civil Engineering Lecture Series for the 1969-70 academic year was opened by George L. DeMent, Chairman of the Board of the Chicago Transit Authority, who spoke on the "Problems and Progress of Mass Transportation in Chicago." Future speakers for the program include: Ronald F. Scott, Professor of Civil Engineering at the California Institute of Technology; John C. Guillou, Chief Waterways Engineer for the State of Illinois; John B. W. Corey, Administrative Assistant to the Office of the Mayor of the City of Chicago; Frank W. Bowerman, Vice-President of Zolin Industries in Philadelphia; John M. Kyle, Jr., Chief Engineer for the Port of New York Authority; and Edward Wenk, Jr., Executive Secretary of the National Council on Marine Resources and Engineering Development.

The series for this year was arranged by a committee under the chairmanship of Professor Ralph B. Peck, of the University of Illinois Department of Civil Engineering. The speakers have been given a free choice of topics across the breadth of civil engineering, and there isn't any charge to hear them. ◆

OF ROADS AND RIVERBEDS

One of the problems with road building is that the available materials are not always suited to the job. In South Vietnam, especially around the Mekong River Delta, the earth is covered with alluvial clays which lack the qualities needed for good road construction.

Professor Marshall Thompson of the University of Illinois Department of Civil Engineering recently made a three-week trip to Saigon, the Mekong Delta, and several other spots as a consultant to the U.S. Navy Military Assistance Command in South Vietnam. Professor Thompson has been conducting research in lime soil stabilization since 1960.

Sources of gravel and other aggregate materials are very limited in the Delta area, and importing these materials is not a feasible solution. By adding hydrated lime ($Ca(OH)_2$) to the alluvial clays, they can be made suitable for building highway pavement. Professor Thompson's recommendations in the areas of construction methodology, mixture design, and pavement analysis and design are expected to be widely utilized in future Delta construction programs. ◆

Harprit Sandhu (left), a research fellow in ceramic engineering, is holding a piece of silica brick from the roof of an open-hearth furnace. The dark coloration of part of the brick is caused by deposits from the furnace during its service life. The photomicrograph (right), made with a scanning electron microscope, shows a vapor-deposited ferrite dendrite. Sufficient deposits can force the replacement of used bricks.

PEOPLE AND PLACES

Professor **John E. Baerwald** of the Department of Civil Engineering, has been named president of the Institute of Traffic Engineers after having served as administrative vice-president during the previous year. The announcement was made at the thirty-ninth annual meeting of the international organization in Los Angeles. Professor Baerwald is the Director of the Highway Traffic Safety Center and Professor of Traffic Engineering at the University of Illinois.

The 1969 Machine Design Award of the American Society of Mechanical Engineers will be presented to Professor **Eugene Radzimovsky,** of the Department of Mechanical and Industrial Engineering, at the Winter Annual Meeting of the Society in Los Angeles. The award is given "for distinguished additions to the literature of machine design . . . and for stimulation of the creative efforts of others. . . ."

The University of Illinois and forty-eight other universities have formed a national consortium to foster cooperation among research organizations, the United States government, and universities for the advancement of space research. The consortium, entitled the Universities Space Research Association (USRA), functions under a Council of Institutions composed of an official representative from each member university. Professor **Herbert E. Carter,** Vice-Chancellor for Academic Affairs at the Urbana-Champaign campus, has been selected as the representative from the University of Illinois.

USRA expects to foster the development of laboratories for research and education associated with space science technology and to serve as a liaison between the member institutions and the Lunar Science Institute recently established in Houston, Texas. Michigan State University, Northwestern University, the University of Michigan, the University of Chicago, and the University of Illinois are included in one of its nine regional groups.

Professor **William L. Hull,** of the Department of Mechanical and Industrial Engineering, has been elected to a three-year term as Director of the Society of Automotive Engineers, Incorporated. Professor Hull has been a member of the Society since 1936 and has served on its national committees for diesel engine activities and educational activities. As its name indicates, the SAE deals not only with automobiles but with any vehicles that move under their own power.

Professor **Raj Mittra,** of the Department of Electrical Engineering, recently served as a member of the five-man U.S. delegation to a group discussion with British workers in the field of electromagnetics. The discussion was held in September prior to the European Microwave Conference at which Professor Mittra presented a technical paper. **Dr. Tatsuo Itoh,** of the University of Illinois Antenna Laboratory, was coauthor of the paper. Earlier in the year, Professor Mittra attended the Sixteenth General Assembly of the International Union of Radio Science as one of seven University of Illinois professors serving with the United States delegation. ◆

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ENGINEERING OUTLOOK

at the University of Illinois at Urbana-Champaign

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 11, NO. 3 NOVEMBER 1969

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In the order listed, this issue contains articles on the following subjects:

A NEW INFORMATION SYSTEM FOR THE COLLEGE
THE ELECTRO-AERODYNAMIC PRECIPITATOR
AN INSTRUCTIONAL LABORATORY FOR MACHINE DESIGN

TO BE SO GOOD AND GENIRAS

Almost everyone in administrative work has been faced with the problem of knowing that some information exists without knowing how to get to it conveniently. To alleviate this problem, the College of Engineering has been responsible for developing an automated system for information handling and processing. Called GENIRAS (Generalized Information Retrieval and Application System), it eventually may be used by the entire Urbana-Champaign campus of the University. Even in its present form, the system is flexible enough to be applied to the records of any organization maintaining large quantities of statistical information.

The first phase of the project, begun in 1967, involved a thorough study of the data kept by the College of Engineering. Useful items of data had to be defined, the sources for collection had to be determined, and their validity had to be established. Finally, the optimum methods for processing and display had to be selected. The determination and creation of the processing capabilities then became the second phase of the development.

In addition to providing a programming system that allows the listing, summing, averaging, graphing, and projecting of stored data, the work of the second phase resulted in a programming language which could be used by an inexperienced person after only a few hours of instruction. Called GENIRAL-1, the language relies on simple, descriptive terms for the computer operations that allow the user access to all the capabilities of the system. Certain of the program instructions even permit a user to ask the machine to reprint sections of the instruction manual for the language. With remote terminals from which operators can communicate directly with the computer, the system would allow its users to learn and to employ new capabilities as they are needed.

Upon completion of its development within the College of Engineering, GENIRAS will be examined in terms of its applicability to the needs of the entire campus. In response, the developers of GENIRAS have outlined a method for analyzing and defining the requirements of information systems. GENIRAS reflects an attempt to create a framework for handling and processing the data maintained by any educational institution.

With most of the requirements of the first system already met, the project work recently moved into expanding and improving the existing capabilities through a new system, GENIRAL-2. A language being developed for GENIRAS-2 would use instructions resembling natural, grammatical English. For example, the statement, "compare 'estimated expenses' against 'real expenses,'" would result in an item-by-item comparison between the elements of the group of "estimated expenses" against the elements of the group of "real expenses." Such simplifications for the user allow complex statistical analyses and mathematical manipulations to be performed and graphical displays of the results to be created with the least amount of confusion resulting from the programming language.

Since all of the data processing merely represents an attempt to clarify the past to create an idea of the future, the possibility of including automated optimization and decision-making capabilities is being investigated. These features would build on the work completed for GENIRAS-1 and continuing on GENIRAS-2 and would be incorporated into a third form for the computing system. Use of the masses of data which have been meticulously maintained should prove to be a much less serious problem with the help of a computer made so readily available. ◆

EVERYTHING BUT SIT UP AND BEG

The electro-aerodynamic precipitator, created by Dr. S. L. Soo and research assistant Larry W. Rodgers, has been licensed for development as a commercial product. The precipitator resulted from research by Dr. Soo, a professor of mechanical and nuclear engineering, into improved methods for removing suspended particles from the exhaust aerosols of industrial processes. A small, commercial version of the precipitator is to be developed by United Air Specialists. Commercial development of a small model for automotive applications and of a larger version for the needs of heavy industries remains to be exploited.

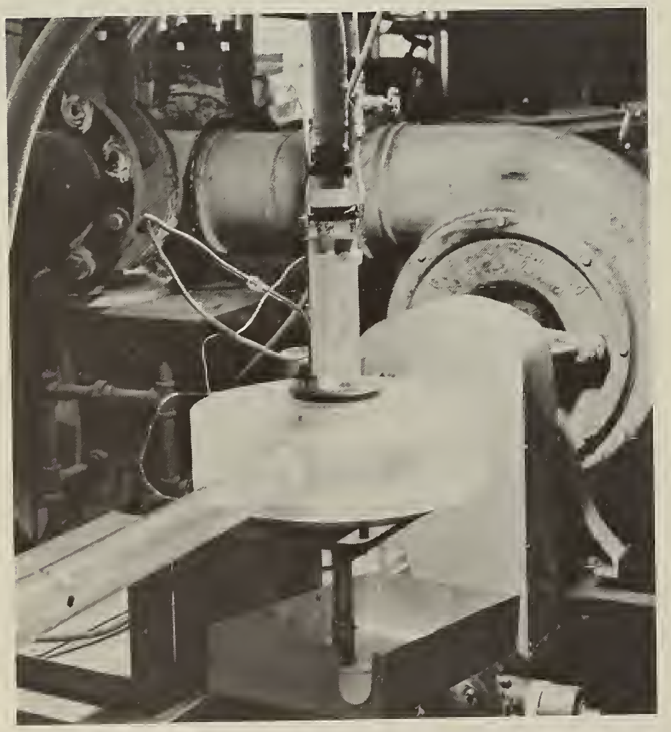
Previous designs of electrostatic precipitators typically use a high-intensity electric field to charge the pollutant particles in the air and then collect them as they follow the electric field to the collection plates. The operation of present precipitators has changed very little since their development in 1910. The new precipitator overcomes several serious disadvantages of previous designs that, among other things, use stationary plates to collect the particles.

One of the major advantages of the new precipitator is that it is self-cleaning. Older precipitators had no automatic means for continuously removing particles during the collection process. The new precipitator uses plates mounted on a rotating drum like the blades of a squirrel-cage fan. With each revolution of the drum, the blades are brought through a device to wash them with either an air or water stream.

The new precipitator also makes use of an electric field oriented in the direction of the flow of the particles to prevent undesirable electrical side-effects. The efficiency is increased by having the collection plates located in the path of the air flow.

An experimental model of the precipitator used for tests at the University produces the electric corona necessary to charge the particles by applying a high voltage to a ring of alumel wires around the intake port. The ring of wires is fixed in place with the device for washing the plates. The collecting drum is mounted around them and is driven at a speed of only a few rotations per minute. This allows the cleaning mechanisms to operate and prevents the creation of undesirable aerodynamic effects from the rotating blades. Mass-cleaning efficiencies as high as 99 percent have been obtained with this apparatus.

The mechanism used to clean the blades is comparably efficient and is designed to occupy only a small portion of the inner circumference of the rotor. It is designed to use only small amounts of water or air to remove any collected particles — including insulating materials that have



The experimentol model of the electro-oerodynomic precipitotor (left), developed by Dr. S. L. Soo, is shown connected ond reody for loborotory testing. The oerosol — oir contoining the suspended porticles — is fed in through the hose connected to the center of the device, then cleoned ond exhousted through the port in the side. The core of the opporotus (right) shows the wires used to produce the corono ond the fixtures for connecting the oir ond woter to the woshing device.

proven particularly troublesome in conventional precipitators. Materials like alumina or magnesium oxide, often constituents of foundry smoke, build up on the plates and reduce the efficiency of conventional precipitators unless they are cleaned regularly.

When air is used to remove the particles from the plates, the higher-density aerosols produced can be cleaned elsewhere by methods which could not be used directly in the production process. With water as the cleaning agent and the air stream drying the plates, the water could be similarly cleaned by other methods.

Laboratory experiments with aerosols of magnesium oxide dust and water cleaning resulted in a thick, white run-off resembling toothpaste. For certain industrial processes, the water wash would mean easy recovery of the by-products of a process that normally would have expelled them into the atmosphere. The ability of the machine to clean itself with so little water and air is also an encouragement for its use.

Other advantages that make the electro-aerodynamic precipitator more attractive than presently available units include greater operating capacities than present machines occupying the same amount of space. The same proportions apply for applications in the home as well as applications in industry requiring capacities approaching one million cubic feet per minute. The range of particle sizes with which the precipitator can operate efficiently has also been increased as larger particles are collected in a more mechanical manner by the plates moving across the direction of flow.

The electro-aerodynamic precipitator has given every indication of being an efficient and practical device for the prevention of air pollution by exhaust aerosols, and it will probably experience successful development as a commercial product. Together with concurrent efforts at the University of Illinois to produce standards of measurement of aerosol densities, the precipitator constitutes a significant development to combat atmospheric pollution. ◆

TELLING IT LIKE IT IS

The recent restructuring of the Mechanical Engineering curriculum at the University of Illinois has led to the development of a general purpose, instructional laboratory for mechanical analysis and simulation. The new laboratory is designed to accompany the first course in a revised, three-course sequence in machine design and to provide laboratory facilities for several other courses in control systems and the dynamics of machinery. Prior to the development of this laboratory, no facilities existed for instruction in the application of modern machine design techniques.

The laboratory was organized under the direction of Assistant Professor Carl S. Larson, of the Department of Mechanical and Industrial Engineering through funds provided by the National Science Foundation, the Mueller Company, of Decatur, and the University. The laboratory consists of equipment for six operating stations, each of which may be used by three or four students. Fully instrumented demonstration equipment is provided for several of the experiments allowing the students to observe the applicability and limitations of theoretical principles.

In addition to the operating models of machine design elements, the laboratory includes analog computers for machine simulation. Through a recent grant, the laboratory will be equipped with a small analog computer for each of the six stations. The computers will be used to demonstrate mathematical models of simple mechanical systems and to predict the effects of changes in the mechanical systems by creating changes in the computer models.

The level of complexity of the approach to machine design problems will determine the instructional use of the laboratory. The laboratory facilities are sophisticated enough to aid instruction in advanced undergraduate courses and to provide a laboratory environment for graduate investigations in machine design. Graduate students in Mechanical Engineering are allowed use of the laboratory for independent studies in machine element characteristics, and the developments which they produce are transferrable to undergraduate instruction on the same equipment. The laboratory was designed so that such innovations at higher academic levels could be used directly to continuously modernize the instructional material.

The experiments for which the laboratory is presently equipped cover a wide variety of mechanical systems and involve a broad spectrum of design principles. Basic experiments include studies of the mechanical operation of cam-follower systems, characteristics of torsional vibration, and the deformation and critical frequencies of rotating shafts. All of the experiments can include simulation techniques on the analog computers for which instruction is provided during the laboratory sessions.

The importance of the new laboratory is reflected in the experience it gives students to observe real mechanical systems in an environment of creative experimentation with modern laboratory equipment and techniques. ◆

A PUBLIC SERVICE

In order to serve our readers more effectively, the staff of the Engineering Publications Office is soliciting requests for articles on research projects at the University of Illinois. If you would like to see more detailed information about a particular type of research, feel free to suggest that we report on it in a future issue. ◆

THE SECOND COMING

Turning and turning in the widening gyre
The falcon cannot hear the falconer;
Things fall apart; the center cannot hold;
Mere anarchy is loosed upon the world.
The blood-dimmed tide is loosed and everywhere
The ceremony of innocence is drowned;
The best lack all conviction, while the worst
Are full of passionate intensity.

Surely some revelation is at hand;
Surely the Second Coming is at hand.
The Second Coming! Hardly are those words out
When a vast image out of Spiritus Mundi
Troubles my sight; somewhere in the sands
of the desert
A shape with lion body and the head of a man,
A gaze blank and pitiless as the sun,
Is moving its slow thighs, while all about it
Reel shadows of the indignant desert birds.

The darkness drops again; but now I know
That twenty centuries of stoney sleep
Were vexed to nightmare by a rocking cradle.
And what rough beast, its hour come round at last,
Slouches toward Bethlehem to be born?

— William Butler Yeats

The BUILD Conference report on "Engineering, Education, and the Demands of Society" is now available free to members of the staff of the University of Illinois. The report is available to anyone else sending $1.00 to the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. ◆

PEOPLE AND PLACES

Dr. **Shao Lee Soo,** Professor of Mechanical Engineering and of Nuclear Engineering at the University of Illinois at Urbana-Champaign, has been appointed to the Main Committee of the Air Pollution Control Division of the American Society of Mechanical Engineers. The Air Pollution Control Division is concerned with the development of air pollution control standards and regulations.

Professor **Ralph B. Peck,** foundation engineer in the Department of Civil Engineering was elected president of the International Society of Soil Mechanics and Foundation Engineering at its quadrennial meeting in Mexico City. More than 1,500 members of the Society attended the conference at which Professor Peck presented an address on "Tunnels and Deep Excavations in Soft Soil." He will serve a four-year term, presiding over the 1973 conference in Moscow.

One of twelve young university faculty members in the nation honored with a Dow Chemical Company award to attend the American Society for Engineering Education annual meeting, Professor **John T. Pfeffer,** of the Department of Civil Engineering, was named the recipient for the Illinois-Indiana section. ◆

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In the order listed, this issue contains articles on the following subjects:

PARTICLE FUSION
DISPLAY OF THREE-DIMENSIONAL IMAGES
THE BONEYARD CLEANUP DAY
SUMMER INSTITUTE ON ENGINEERING TECHNOLOGY

WHIZZ-BANG

The Charged Particle Research Laboratory on the Urbana-Champaign campus of the University of Illinois has recently begun work to produce nuclear fusion reactions from the collision of particles of matter. The experimentation is being conducted under the direction of Dr. C. D. Hendricks, Professor of Electrical Engineering and of Nuclear Engineering and director of the Laboratory. Also involved with the project are Dr. Arnold W. Dipert, Assistant Professor of Electrical Engineering, and Danny Weidenfeld, a research assistant.

The research will determine whether or not fusion reactions can be a feasible by-product of the collisions of particles of matter much larger than those normally used for such experiments. The substance to be used for the reaction will be lithium deuteride (LiD), a compound of the light metal, lithium, and deuterium, an isotope of hydrogen. The particles will range in size from 0.5 to 50 microns in diameter, almost too small to be seen but still several orders of magnitude larger than their constituent atoms.

There are many problems associated with the creation of such a reaction. The energy required to trigger the reaction is great. The particles will have to be traveling at extremely high velocities before a high yield of fusion reactions will result. With the proposed apparatus, it is expected that less than one molecule in every thousand will undergo the reaction. To increase the yield, some thought has been given to using a high-powered laser to inject more energy at the collision site.

Even before the reaction can be tested, the particles, in the form of fused droplets of the substance, will have to be given an electric charge and injected into an electromagnetic sorter to separate the particles with the desired ratio of charge to mass. The ratio is important since the particles are to be driven to the collision site by linear accelerators. They will not be accelerated at the same rate and will not reach the same collision point from opposite ends of the accelerators if the ratios are not the same.

The device that isolates the particles with the desired charge-to-mass ratio is called an electric quadrupole. It uses an rf electromagnetic field to do the sorting and causes the particles with the desired ratio to move in stable patterns within the instrument. Improperly charged particles will be deposited elsewhere to prevent their interference with the experiments. Once a group of particles has been collected and suspended in the quadrupole, they will be accelerated to collision energies of approximately 1.5 million electron-volts.

The results of these experiments will give valuable insights into the possibility of driving fusion reactions with relatively large particles. Combined with research by the Laboratory into the magnetic confinement of fusion reactions, the relative simplicity of the apparatus may allow practical applications of the tremendous amounts of energy available from such processes. ◆

THE WHOLE STORY

The Summary of Engineering Research for 1969 is now available from the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. *The Summary* briefly describes each of the engineering research activities being conducted in the departments of the College of Engineering, in the major research laboratories, and in the Department of Computer Science of the University of Illinois at Urbana-Champaign. *The Summary* is available free to University students and faculty members and for a handling charge of $1.00 to other individuals and organizations. ◆

IT'S ALL RIGHT, BUT IS IT ART?

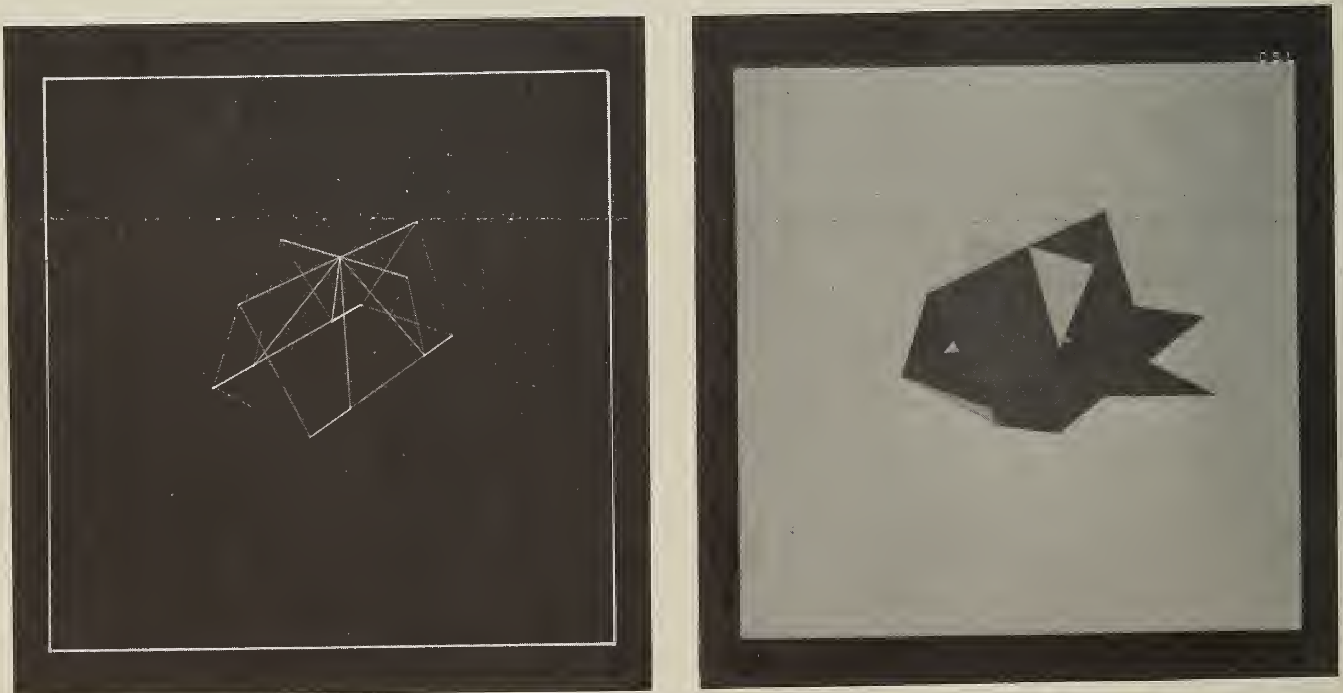
Recent work by Karl C. Kelley and Jack Bouknight, research engineers for the Coordinated Science Laboratory of the University of Illinois at Urbana-Champaign, has resulted in a new technique for the display of three-dimensional images by a digital computer. The new technique, called the shaded LINESCAN, expands on previous work done at the Laboratory toward the development of the LINESCAN routines.

Most computer routines for the display of objects have the disadvantage of displaying only the edges with a "wire frame" image. The framelike picture allows the observer to see through the object to edges that normally would be hidden from view. For complicated structures, this characteristic can seriously impair the ability of the observer to visualize the object being depicted. The new shaded LINESCAN overcomes this difficulty by displaying shadows and opaque planes for a more realistic representation.

The LINESCAN system allows the display of an object from any viewing angle and permits rotation of the object for the generation of a series of images. LINESCAN images are generated from data specifying only the coordinates of the endpoints of edges. Through the use of a special algorithm, the computer itself can generate the information it needs to complete the display. The computer can determine a set of "key squares" which define where changes in the image intensity should take place. Shaded LINESCAN then displays the image on a cathode ray tube by employing a raster-scan technique similar to television pictures except using sampled digital data.

Once the necessary data have been accumulated in the computer to create the image, a programmer has access to the routines to modify the image through either a FORTRAN source program or the operator's console. The shaded image may be viewed from different directions like the original LINESCAN images, and the intensity of the background light may be varied down to zero. The program also allows for the simulation of a point source of light which can be moved and varied in intensity. The background light and the point source permit the operator to view an object under a complete range of lighting conditions both with and without shadows. Program routines also permit an operator to vary the size of the displayed image.

Shaded LINESCAN images are built from the same data supplied for line drawings. The half-tone effect is created through the use of 256 defined levels of gray. In addition, the raster-scan mode permits complete object definition with no more than the specification of intensities and where changes in intensity occur. This capability avoids the problem of providing a value for the intensity at every image point. The problem would have been particularly troublesome with the CSL equipment since LINESCAN pictures are displayed on a square grid of nearly seventeen million individually addressable data points. In compari-



To overcome the lack of realism of the "wire frame" display (left), the recent development of the shaded LINESCAN (right) permits the display of opaque planes with background lighting and with a point source of light for the projection of shadows.

son, the pictures created are roughly sixty-four times finer than the pictures on a commercial television set of similar size.

Though LINESCAN was originally developed for the display of architectural drawings, the quality of the displays and the relative ease with which the system can be programmed and modified should encourage its use in a rapidly growing number of applications. ◆

THE DAY OF THE BIG CLEANUP

Through a special course in general engineering, several engineering students at the University of Illinois have undertaken the project of restoring Boneyard Creek, which runs through the engineering campus, to its original, natural beauty. The course project, under the direction of Bruce M. Hannon, an instructor in the Department of General Engineering, involves nine students who will receive academic credit for their work. The project initially will involve restoring the cleanliness of the stream, after which plans will be developed to prevent its future pollution. To assist in their studies of pollution, the students are reviewing published evidence of pollution and are taking their own samples and data when necessary.

To start the project work and to attract attention to what the students believe is an important effort to redeem the image of engineers, Engineering Council, the engineering student governing body, sponsored a group called Students for Environmental Controls, who organized a Cleanup Day. In response to an open invitation, a group of engineering students met on the banks of the Boneyard to hear William L. Rutherford, Director of the Illinois Department of Conservation. After the speech, some boots and gloves were made available and the cleanup began.

The cleanup efforts received endorsements from both Chancellor Jack W. Peltason, of the Urbana-Champaign campus, and Dean Daniel C. Drucker, of the College of Engineering. In addition, endorsements were received from local chapters of the Sierra Club, the Audubon Society, the Izaak Walton League, the YMCA and YWCA, the Boy Scouts, the Moratorium Committee, and several other groups. Numerous local organizations and civic groups also gave their endorsements, and one, the Urbana and Champaign Sanitary District, supplied trucks to carry away collected refuse.

The engineers behind the project realize that merely cleaning the stream bed will not be sufficient, but that a unified community effort will be required to maintain its restored attractiveness. The efforts toward pollution abatement, beautification, and the disposal of refuse are intended "to draw attention to this local aspect of environmental problems and the alternative solutions . . . to emphasize the Boneyard's potential for development into an asset for the campus and Champaign-Urbana . . . [and] to help stimulate interest in the National Teach-in on the Status of the Environment planned by Senator Gaylord Nelson of Wisconsin for this spring." ◆

MÖSSBAUER SPECTROSCOPY

On March 17 and 18, 1969, approximately one hundred biochemists and physicists met at Allerton House of the University of Illinois to discuss the applications of Mössbauer spectroscopy in biological systems. Seventeen of the talks given at the meeting are summarized in the proceedings, which are now available for $3.00 from the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801.

Since Mössbauer spectroscopy is particularly well suited for the study of iron compounds, the central theme of the discussion was the role and structure of biomolecules containing iron, specifically heme proteins and iron-sulfur proteins. These molecules contain iron in their active centers, and the Mössbauer effect lends itself to a study of their biological activity.

The meeting attempted to serve the dual purpose of bringing a relatively recent technique to the attention of biologists and to acquaint physicists with the relevant problems in biochemistry. To bridge the communication gap between physics and biology, a number of experts from both fields were invited to outline, in a language comprehensible to the nonexpert, the present state of knowledge in their field and the different methods of approach. In addition there were contributions covering related topics and recent results. ◆

TEACHING ABOUT TEACHING

The University of Illinois at Urbana-Champaign will offer its tenth Summer Institute on Engineering Technology for Junior College and Technical Institute Teachers from June 22 through August 15. This year, fifteen teachers will receive intensive training in machine design technology, and another fifteen will receive corresponding training in electronics technology. Each teacher will receive a $600 stipend with additional allowances for travel and dependents. In addition, the Institute work will be applicable toward the post-baccalaureate Certificate in Teaching of Engineering Technology offered by the University. The deadline for applications for admission is February 15.

The institutes are part of a nationwide effort of the National Science Foundation to meet an acute shortage of well prepared teachers of engineering technology. Over the decade, grants from the NSF have exceeded one-half million dollars with the latest grant of $55,600. The funds have been used at the Urbana-Champaign campus of the

University to provide programs for nearly four hundred teachers from across the country.

Professor Jerry S. Dobrovolny, Head of the Department of General Engineering, has directed the institutes since they began. The associate directors of the Institute will be Professor Edward L. Broghamer, of the Department of Mechanical and Industrial Engineering, and Professor Daniel S. Babb, of the Department of Electrical Engineering. ◆

PEOPLE AND PLACES

Professor **Nathan M. Newmark,** Head of the Department of Civil Engineering, and Professor **John Bardeen,** of the Department of Physics have been appointed members of the Visiting Committee for 1969–70 by the Board of Overseers of Harvard University.

Professor **Ralph B. Peck,** of the Department of Civil Engineering has been given the Karl Terzaghi Award for his contributions to the literature, to teaching, and to the practice of soil mechanics and foundation engineering.

The American Society of Civil Engineers has selected Professor **Arthur R. Robinson** to be the recipient of a Walter L. Huber Research Prize. Professor Robinson was cited for "his research on the application of mathematics and mechanics to the solution of engineering problems."

Professor **George W. Harper,** of the Department of Mechanical and Industrial Engineering, has been appointed secretary-treasurer of the recently established Board of Certified Safety Professionals of the American Society of Safety Engineers. The new board is charged with the selection and administration of criteria for the certification of professional safety workers. Professor Harper has said that such a professional certification program had been discussed for nearly a decade before its establishment with the creation of the Board.

Dean **Daniel Alpert,** of the Graduate College, is one of five new members elected to the board of trustees of the Argonne Universities Association. The new members were selected by representatives from the thirty universities of the Association. ◆

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In the order listed, this issue contains articles on the following subjects:

FATIGUE TESTING
COMPUTERIZED DATA-PROCESSING FOR CONTRACTORS
THREE CONFERENCES TO BE HELD
PLATO

FATIGUING

Full-scale fatigue testing of entire structures such as the wing of an aircraft is time-consuming and costly. To alleviate this problem, researchers at the University of Illinois are trying to develop analytical and testing methods to reduce the amount of full-scale testing necessary to maintain confidence in a structure.

The project, under the direction of Professor JoDean Morrow, of the Department of Theoretical and Applied Mechanics, is concerned with the prediction, from laboratory experiments on simple metal specimens, of fatigue failure in complicated, full-scale structures. Since 1965, the Aeronautical Structures Department of the Naval Air Development Center has contributed approximately $218,000 toward research along these lines.

The experimental apparatus, employing advanced, closed-loop electro-hydraulic test equipment, is being used to create either programmed or random loading histories and to simultaneously plot the cyclic stress-strain curves generated during the test. Since fatigue is the name given to fractures resulting from repeated loading of structural material, the random loading closely simulates the conditions experienced during the normal operation of all types of transportation equipment. Continued loading can result in the formation of tiny cracks in regions such as rivet holes where cyclic stress is high. After thousands of load applications, the cracks may grow, spread, and cause the structure to fail.

Without using actual pieces or sections of finished structures, representative samples of metals used in structures are being studied to develop general rules for the prediction of behavior. In addition to the electro-hydraulic testing, an effort is also being made toward digital computer simulation.

Present studies are being conducted on metals commonly used in the construction of aircraft, and the results of this research should be directly applicable to such problems as the safe design of aircraft for commercial travel. ◆

NEW SYSTEM AUTOMATES HEAD-SCRATCHING

For many years, the Civil Engineering Systems Laboratory (CESL) of the University of Illinois at Urbana-Champaign has been engaged in research on modern management and data-processing techniques for contractors. The staff of the laboratory, interested in producing research results that are directly usable by professional contractors, have concentrated on the development of computer-based systems that can be reached and employed directly from terminals in the contractors' offices.

During the past three years, through a cooperative effort involving the University, the U.S. Department of Commerce, and participating contracting and engineering firms, the staff of the laboratory have developed such a major system. The participating firms now have on-line access, through teletypewriter terminals in their offices, to a time-shared computer at CESL. They communicate with the computer in a natural, problem-oriented language especially designed for their own particular problems. Responses from the computer, including error messages, are received immediately. Complete security of each firm's information is also maintained.

The construction management portion of the system involves four major functions, three of which are concurrently operational. The *payroll* function handles all record keeping necessary to produce periodic or special reports, including checks, union, insurance, and government reports, and labor and productivity information. The *accounting* function handles all general accounting operations and reports, including expense accounts for jobs processed through the *payroll* function. Simultaneously, the *CPM* function allows for the planning and monitoring of jobs. The fourth function, *estimating,* when integrated with the other three, makes use of historical records based on previous jobs.

With the initial system completed, CESL is now in a position to demonstrate the system and expand its cooperative base by accepting a number of new participants. Any participant should expect to use the system on a day-to-day basis and should be willing to cooperate in its development and extension.

Further information or a demonstration of the capabilities and applicability of the new system may be obtained by writing: A. C. Brooks, 203 Engineering Hall; L. T. Boyer, 303 Engineering Hall; or S. J. Fenves, 201 Engineering Hall, University of Illinois, Urbana, Illinois 61801, or by phoning (area code 217) 333-2465. ◆

ELECTRONICS TECHNOLOGY CONFERENCE

New teaching materials and ideas for courses for electronics technicians will be presented in a three-day Electronics Technology Conference to be held February 25 to 27 at the University of Illinois at Urbana-Champaign. The conference is being conducted in conjunction with a thirteen-month project, supported by the National Science Foundation, to develop instructional materials and techniques for the basic circuits and electronics courses of associate degree programs in electronics technology. The project work is taking place in the classrooms and laboratories of Parkland Junior College in Champaign and in cooperation with several other Illinois junior colleges.

Professor Daniel S. Babb of the Department of Electrical Engineering, director of the project, has announced that the conference will be of direct interest to electronics teachers, school administrators, guidance counselors, and industrial personnel. It will include a discussion of electronics education in the United States and will emphasize the interactions of industry and community colleges in developing curricula and in identifying job opportunities for graduates. Further information about the conference may be obtained by writing to Professor Babb, 355 Electrical Engineering Building, University of Illinois, Urbana, Illinois 61801, or by phoning (area code 217) 333-4340. ◆

BACK-TO-BACK

The Fifty-sixth Annual Illinois Highway Engineering Conference and the Twenty-second Annual Illinois Traffic Engineering Conference will be held on four consecutive days beginning February 24. The first two days of the period will be devoted to the Highway Engineering Conference and include general sessions in the mornings and group meetings in the afternoons. According to Professor Ellis Danner of the Department of Civil Engineering, conference coordinator, the highlight of the program will be the general session on the second morning. Entitled "Tooling Up for the Illinois Highway Program of the Seventies," it will be a panel discussion with several individuals from the business, legal, and professional world associated with highway engineering.

The Traffic Engineering Conference, immediately following the conference on highway engineering, will have similar general sessions with simultaneous workshop sessions scheduled for the morning of the second day. The conference coordinator is Professor John E. Baerwald of the Department of Civil Engineering and Director of the Highway Traffic Safety Center of the University of Illinois at Urbana-Champaign. Inquiries about either conference may be addressed to the University Extension Division, 116 Illini Hall, University of Illinois, Champaign, Illinois 61820. ◆

PLATO

With the great promise of computer-assisted education already demonstrated by the existing PLATO (Programmed Logic for Automatic Teaching Operations) system, the Computer-based Education Research Laboratory of the University of Illinois has undertaken the development of PLATO IV to greatly expand the system's present capabilities and to attempt to alleviate the problem of high cost.

The existing PLATO III system serves seventy student terminals connected to a high-speed Control Data Corporation 1604 Computer. The system has been used to teach such subjects as mathematics, chemistry, biology, library science, electrical engineering, and nursing. The computer system also possesses the particularly useful ability to simulate laboratory experiments. This feature has proven especially helpful to students of nursing who have been able to manipulate conditions which could be dangerous to produce in actual, clinical situations.

Professor Donald Bitzer, director of the laboratory, declares that computer-based education has captured the enthusiasm of students and teachers. "The interactive nature of this instructional medium typically absorbs the attention and encourages the total involvement of students at all age and grade levels." He says that, "The student may proceed at his own pace and can exert considerable choice in the selection of alternative teaching strategies and methods of presentation."

The present PLATO student terminal consists of a television-like screen and a keyset. Information viewed on the screen is composed of a slide selected by the computer and a superimposed image of pertinent graphs, diagrams, and alphanumeric characters drawn by the computer in a point-by-point fashion. The student uses the keyset for constructing questions and answers, for setting up simulated or real experiments, and for controlling his progress through the lesson material. The computer responds to a student's request within one tenth of a second.

In addition to keeping detailed records of student performance, the computer can provide individualized instruction, immediate feedback, and remedial training. These unique features seem to make the computer an ideal instructional device for developing cognitive skills. Teachers like the method because it provides feedback for them as well as for the students. More importantly, even teachers with no previous experience in computer programming have found that they can prepare lesson materials after only a few hours of familiarization with the system.

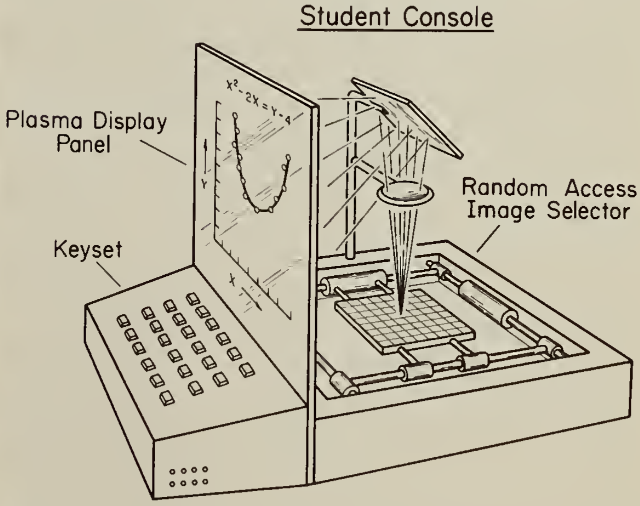
The technological advances of the PLATO IV system include the addition of audible instruction to supplement the visual media. In addition, the television screen at the student terminal will be replaced by a plasma panel designed to display computer-generated graphics with the simultaneous projection of photographic images on its surface. Another innovation, a random-access image selector, permits immediate access to any image for projection from a square grid of 256 such images. The ability to select quickly any slides from the instructional material, in any order, insures speed and flexibility for the system.

The plasma panel (*Outlook,* November 1967), invented by Professor Bitzer, Professor Gene Slottow, and Robert Wilson, in the Coordinated Science Laboratory, is composed of three sheets of glass. The center sheet is made with a grid of tiny holes containing a gas which can be ionized under the control of transparent, electrically-conducting strips orthogonally arranged on the outer glasses. The computer drives the plasma panel and creates displays of charts, diagrams, and alphanumeric charactérs. Use of the plasma panel promises to reduce considerably the cost of individual student terminals. The inherent memory of the plasma panel will lower the data rate required by the new terminal to be within the capabilities of standard, voice-grade telephone lines.

The present student terminals of the PLATO III system cost about $8,000 each. It is estimated that the PLATO IV terminals, produced in quantity, will each cost approximately $1,500. The projected PLATO IV system will serve four thousand of the new terminals (two thousand in the Champaign-Urbana area) and, when operated, is expected to cost less than fifty cents per hour of instruction.

"A single PLATO IV system operating ten hours a day could provide approximately 10 million student-contact hours annually at a cost of about $3 million, with a total capital investment of approximately $12 million," Bitzer says. "This is equivalent to the entire annual instructional load of a four-year undergraduate institution with 24,000 students! Such an institution would typically have direct instructional expenses of well over $20 million annually, and in a university setting, a total budget several times greater."

Bitzer is quick to point out, however, that he is not suggesting that PLATO will replace the university. Rather, he wants to indicate that a single PLATO IV system could augment by 20 percent the instructional capacity of five such institutions on a budget of less than $1 million each.



Pupils at Washington Grade School in Champaign, Illinois (left), use the existing consoles of the PLATO III system. The boy, who raised his hand to summon the teacher, is receiving help from a classmate. An artist's conception (right) of a console for the PLATO IV system shows the two new display elements — the plasma display panel and the random-access image selector. The PLATO IV system also will include new provisions for audible instruction to supplement the visual media.

"This added capacity could relieve an equivalent portion of faculty time for developing new programs, teaching in smaller group settings, or providing extra help to individual students," Bitzer says. "The possibility of such an enrichment to our national educational capability has provided added incentive to our efforts to implement and test the PLATO IV design and to learn how such a system would function and contribute in a variety of educational settings." ◆

ENGINEERING OPEN HOUSE

The College of Engineering of the University of Illinois at Urbana-Champaign will be holding its annual Engineering Open House on Friday and Saturday, March 6 and 7, between 10 a.m. and 3 p.m. on Friday and 9 a.m. to 3 p.m. on Saturday.

Some departments have provided special exhibits for the public, particularly the departments of Electrical Engineering and Agricultural Engineering. The remaining departments will allow interested people to visit their classrooms and laboratories. Over 1,300 letters have been sent to high schools inviting students interested in engineering to attend the Open House.

Information about where to go and what to see may be obtained from the chairman of this year's Open House Committee, Professor Paul R. Egbert, 349 Electrical Engineering Building, University of Illinois, Urbana, Illinois 61801. ◆

PEOPLE AND PLACES

William L. Everitt, Dean Emeritus of the College of Engineering, has received one of two awards of merit presented at the 1969 National Electronics Conference. The Award of Merit was presented by the Board of Directors of the conference, "In recognition of an outstanding career marked by sustained contributions in the education of young engineers and in bringing the benefits of modern electrical technology to the community at large."

Nine winners of special fellowships from the Atomic Energy Commission have chosen to attend the University of Illinois at Urbana-Champaign. Six of the first-year graduate students will be studying nuclear science and engineering, which includes nuclear physics, nuclear chemistry, nuclear engineering, plasma physics, and related fields. Three of the fellowship winners will be undertaking graduate study in health physics which involves the identification, evaluation, and prevention of the effects of nuclear radiation. The students, members of a group of ninety-four fellowship recipients, were free to select the institution which they wished to attend. ◆

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ENGINEERING OUTLOOK

at the University of Illinois at Urbana-Champaign

RESEARCH
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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 11, NO. 6, FEBRUARY 1970

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In the order listed, this issue contains articles on the following subjects:

RESEARCH PREPARATIONS FOR THE SOLAR ECLIPSE
REORGANIZATION AND AUTOMATION OF STRUCTURAL SPECIFICATIONS
CIVIL ENGINEERING LECTURE SCHEDULE

DARKNESS AT NOON, ALMOST

What happens in the ionosphere when the lights go out? That question may be answered on March 7 when a solar eclipse, whose path of totality will extend from Florida to Virginia, will give University of Illinois scientists a chance to observe, in a matter of minutes, changes which usually take hours to occur in the earth's ionosphere. The sun's rays play a large part in the forming of the ion plasma making up the ionosphere. Researchers from the Ionosphere Radio Laboratory, Radiolocation Research Laboratory, and the Aeronomy Laboratory at the Urbana-Champaign campus are involved in a concentrated effort to monitor and record the high-speed changes occurring as the moon comes between the earth and the sun. A variety of sophisticated research instruments will be used for the experiments including a NASA geostationary satellite, a huge circular radiolocation antenna array located at Urbana-Champaign, and rockets fired into the ionosphere from Wallops Island, Virginia.

The Ionosphere Radio Laboratory headed by Professor K. C. Yeh will be sending research teams to two sites in the path of total eclipse. One team will be situated at Turkey Point, Florida, where facilities at a marine station owned by the University of Florida have been lent to the researchers, while the other team will observe the eclipse from a naval installation at Norfolk, Virginia. The teams will observe the eclipse from their respective positions just as darkness begins along the path of totality over the continental United States at 1:18 p.m. EST, and as it leaves the mainland at 1:36 p.m. EST. The researchers will really have to be on their toes since the shadow of the eclipse will cover the East Coast at about 40 miles per minute taking 18 minutes to race across the approximately 700 miles between Florida and Virginia.

An important part of the Ionosphere Radio Laboratory experiment is NASA Geostationary Satellite ATS3 (called geostationary because it orbits at the same rate of speed as the earth's rotation). Radio waves transmitted by ATS3 will then travel back through the ionosphere and register on a polarimeter, an instrument designed to measure the degree of polarization of the waves and indirectly measure the ionization of the atmosphere during the eclipse.

Basic research may be the goal of all three investigations into ionospheric phenomena during the eclipse, but at least one of the labs has a specific interest in radio wave propagation in the upper atmosphere during the blackout. Professor A. D. Bailey and the Radiolocation Research Lab are involved in research into radiolocation, a process by which the source of a radio emission can be located accurately using measurements made on the signals arriving at a receiving site. Since high frequency radio signals cannot follow the curve of the earth, long-range shortwave communications take advantage of the properties of the many-layered ionosphere to bend their waves back down to a receiver based on the earth. Radio direction finders like the one located at a 40-acre site 8 miles west of the Urbana-Champaign campus use their antennas to scan the horizon several times each second to collect energy from these reflected radio waves. The distress signal of a sinking ship or a downed airplane can be picked up and the probable point of its origin located fairly accurately using the 120 antennas of the 993 foot circular array direction finder.

Professor Bailey points out that this is not all as simple as it sounds due to certain irregularities in the ionosphere causing random or unexpected bending of radio signals. These irregularities may be influenced by temperature changes, gravity waves, sunspots, the change from night to day, and the solar eclipse. By pulling in radio signals which bounce off the ionosphere directly over the path of totality, the Radiolocation Research Lab will be attempting to study ionosphere-induced inaccuracies in radio direction finding. Professor Bailey indicated that a broadcast originating somewhere in the southwest Atlantic Ocean like Bermuda would provide a good source of radio waves for the experiment. It is expected that the angle of the wave's departure from the ionosphere will correspond to predictions of several existing theories, thus enabling scientists to test the validity of corresponding models and possibly contribute to more precise radio direction finding.

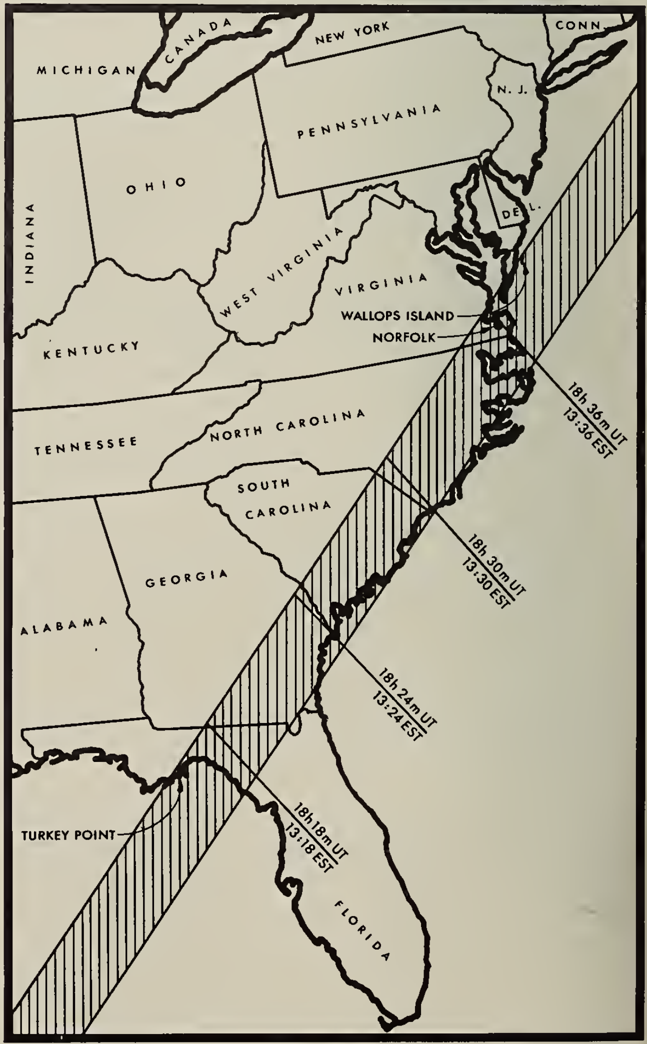
While the Ionosphere Radio Lab and the Radiolocation Research Lab will both be conducting ground-based experiments, the Aeronomy Lab headed by Professor Sidney A. Bowhill will be using its stable of Nike-Apache rockets to monitor the effects of the eclipse in the ionosphere. The rockets to be launched March 7 will be the thirty-third through the thirty-seventh that have carried University of Illinois research instruments since 1964. While some of them have been shot from other places, including a ship in the Pacific, most have been fired from Wallops Island, where NASA has extensive tracking and telemetering facilities. Wallops Island, Virginia, will provide launching pads for thirty-three rockets to be fired by various agencies interested in ionospheric research.

The first Nike-Apache rocket to be fired during the experiment will go off at 10:45 a.m. EST, during full sun before the eclipse. This shot will provide a control for the rest of the experiment. The second rocket will go 50 seconds later and the third will go at 1:40 p.m. EST. The rockets will be in the air for approximately seven minutes and will reach a height of about 200 kilometers before beginning to lose altitude. They will not be retrieved because it is less expensive to build them than to recover them from the ocean where they have fallen.

The Aeronomy Lab's experiments are designed to provide data concerning the effects of the solar eclipse on the absorption of radio waves in the ionosphere. The ionosphere is a much more effective reflector at night because the ionization which causes radio signals to be absorbed during daylight hours is absent in the hours of darkness. The eclipse will be a little model of what happens in the ionosphere during the change from day to night and back again.

Research instruments on board the Nike-Apache rockets will include radio receiving and transmitting equipment which will measure the Faraday rotation and differential absorption of the radio waves broadcast from the launch site. These measurements will specifically include a calculation of electron concentrations in the ionosphere and the frequency of electron collisions.

The launching of the University's four rockets on March 7 will be the highlight of 1970 research for which the National Aeronautics and Space Administration just granted $250,000 to the Urbana-Champaign Aeronomy Laboratory. The grant also provides funds for adding an electronic computer to facilities at the University's Aeronomy Field Station, 5 miles northeast of the campus, where intensive day by day studies are being made of the ionosphere 100 miles above the earth. The quarter-million-dollar grant also will support other aeronomy research which NASA has backed since 1962 at the University of Illinois. Additional funds are received for the research from the National Science Foundation. ◆



A segment of the path of totality for the solar eclipse on March 7, 1970.

DECISIONS, DECISIONS. . . .

Design specifications have been used traditionally as a principal guide to engineers. National specifications, such as the American Institute of Steel Construction (AISC) Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings, have been incorporated in many local and regional building codes, and thus serve both as a compendium of knowledge and as a legal criterion for checking designs. Specifications have been written for use by experienced engineers, who are expected to supplement the information from their own experience and judgment, as a guide in the design process. As more and more of the design activities are performed by digital computer programs, many inconsistencies and much duplication of effort arise as each organization attempts independently to interpret the missing or ambiguous portions of the specifications and to develop its own computer program.

The issuance of a new, thoroughly revised 1969 edition of the AISC Specifications afforded an opportunity to try a different approach. In the fall of 1967, a group under the direction of professors S. J. Fenves and E. H. Gaylord of the Department of Civil Engineering undertook the development of a new form of documentation for the Specifications. Working under a grant from the AISC, and in close liaison with the Specification Committee, of which Professor Gaylord is a member, the University of Illinois group produced a report presenting the Specifications in the form of 107 decision tables. These tables display at a glance, in a clear-cut and rigorous fashion, all of the logical decisions implicit in the Specifications. Under these tables, computer programs can be readily developed to handle the thousands of interrelated, detailed tests and calculations. It is expected that this form of presentation, as a supplement to the text of the Specifications, will clarify its intent and be used in the formulation of subsequent revisions.

A companion report produced on the subject describes a computer program for processing specifications such as the AISC code. The program, in a sense, mimics the engineer's normal activity. It continues to check and calculate according to the decision tables, until it needs a quantity which has not been specified. At this point it interrupts the process, leaves a "place marker," and transfers to another table which contains the "instructions" for calculating the particular quantity. When the quantity is finally available — during which process many additional, intermediate place markings and transfers may take place — it returns to the point where the previous activity was suspended and continues from there. The program also "learns" as it works, in the very limited sense that it never has to repeat a calculation unless the data on which it is based have been changed by the designer. ◆

CIVIL ENGINEERING LECTURE SERIES

A program of guest lecturers, established by the Civil Engineering Alumni Association during the 1968–69 academic year, has been continued for 1969–70. The objective of the series has been to bring topics of engineering interest to graduate and undergraduate students as well as the general public. Professor Ralph B. Peck of the Department of Civil Engineering, chairman of this year's program committee, has scheduled several outstanding speakers for the second semester.

On March 19, 1970, Frank R. Bowerman, Vice-President of Zurn Industries, Incorporated, will discuss "Changing Technology in Solid Wastes Management."

On April 14, John B. W. Corey, Administrative Assistant, Office of the Mayor, Chicago, will discuss "A Lake Michigan Airport for Chicago."

And on May 12, Edward Wenk, Jr., Executive Secretary of the National Council on Marine Resources and Engineering Development, will discuss "Technology to Use the Sea."

The lectures, to be held in the Illini Union Building, will be scheduled in the evening so that students, faculty, and all interested persons may attend. Specific information about the time and place of a lecture will be publicized well in advance. ◆

ADVANCED CIVIL ENGINEERING PLANNING TECHNOLOGY

The proceedings of a short course in Advanced Civil Engineering Planning Technology are now available for $3.00 from the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801.

The emphasis of the short course was on systems planning in the field of civil engineering and included three main subject areas: planning theories, including probability theory and decision theory; planning techniques, including mathematical modeling and computer analysis; and planning procedures including information processing, mathematical programming, scientific management, planning strategies and systems analysis.

Included in the proceedings with a detailed discussion of the aspects of systems planning are case studies demonstrating the application of these methods to a wide variety of civil engineering problems ranging from structural design to a study of water resources.

The course, directed by professors Ven Te Chow and Ben B. Ewing of the Department of Civil Engineering, was sponsored jointly by the department and by the Office of State Technical Services of the U.S. Department of Commerce. ◆

PEOPLE AND PLACES

The Highway Research Board has presented the A. W. Johnson Memorial Award to Professors **Marshall R. Thompson** and **Barry J. Dempsey** of the Department of Civil Engineering. The award is presented to young researchers in the field of soils, geology, and foundations. This award was specifically based on the paper, "Autogenous Healing of Lime-Soil Mixtures," authored by Thompson and Dempsey and presented at the January 1969 meeting of the board.

One of the two new members of Harvard University's executive administrative body, the Harvard Corporation, is Professor **Charles P. Slichter** of the Department of Physics. Professor Slichter, a Harvard graduate, is internationally known in the field of solid state physics and in his area of specialization, magnetic resonance.

There will be no change in his teaching and research functions at the University of Illinois when, on September 1, he begins his responsibilities on the eight-member board.

Two new chapters of the **Junior Engineering Technical Society** have been chartered in Illinois. David C. O'Bryant of the Department of General Engineering, director of the organization's state headquarters at the University of Illinois at Urbana-Champaign, announced the new chapters, which he said are the one hundred ninth and one hundred tenth in Illinois. The Junior Engineering Technical Society (JETS) is a nonprofit, national organization for high school students who plan to study engineering. "What 4-H Clubs do for agriculture and homemaking, JETS does for engineering," O'Bryant explained. ◆

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 11, NO. 7, MARCH 1970

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In the order listed, this issue contains articles on the following subjects:

CARBON-OXYGEN FUEL CELLS
UNDERGRADUATE RESEARCH IN ENGINEERING MECHANICS
HYDROSYSTEMS LABORATORY EQUIPMENT
A BOOK, MONEY, AND PROGRESS

NO MOVING PARTS

Increased emphasis on the control of thermal pollution and rapidly diminishing fuel supplies have created the need for a new kind of system to generate electrical power. In response to this demand, Professor Shoa L. Soo and research assistant John E. Koch currently are studying the properties of a carbon-oxygen fuel cell. The cell, using the combustion flame as its electrolyte, was invented by Professor Soo and Dr. G. M. Colver, formerly of the Department of Mechanical and Industrial Engineering. The research is being supported by the National Science Foundation.

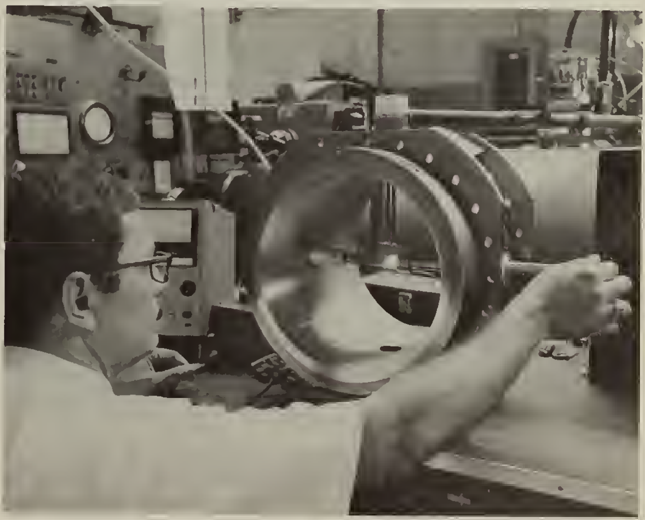
Experiments with a laboratory model have yielded only small amounts of power, but they have given the researchers reason to believe that the process may be scaled up to generate more practical amounts. The present fuel cell model has produced an open-circuit voltage of 1.4 volts and a short-circuit current of 0.25 milliamperes.

The power is generated across a carbon rod serving as the anode or positive terminal and a porous nickel electrode serving as the cathode. Oxygen is passed through the porous nickel electrode and reacts at high temperature with the carbon. The flame produced has been measured optically and with thermocouples to have a temperature of 2600 degrees Fahrenheit.

The fuel cell being used for experimentation is built into a cylindrical chamber with transparent ends to facilitate spectrographic analysis of the reaction products. The chamber also permits the atmospheric pressure around the flame to be reduced, and the best results have been obtained with operation in a partial vacuum.

The oxygen flame, used as the electrolyte, transports the electrons by electron attachment at the surface of the nickel electrode and by collision with free electrons in the region between the two electrodes. The free electrons are generated by thermionic and photo-emission. Since the energy, called the work function, necessary to cause the emission of electrons by nickel is higher than the affinity of oxygen atoms for the electrons, a high temperature of about 1200 degrees Fahrenheit is necessary at the nickel electrode. The deleterious effects of an excessive space charge in the electrode gap were reduced by operating the cell in the partial vacuum.

Since, ideally, the only reaction product of such a fuel cell is carbon dioxide — a relatively innocuous atmospheric constituent compared to the chemicals released by the combustion of natural fuels — the air pollution resulting from power generation would be relatively lower.



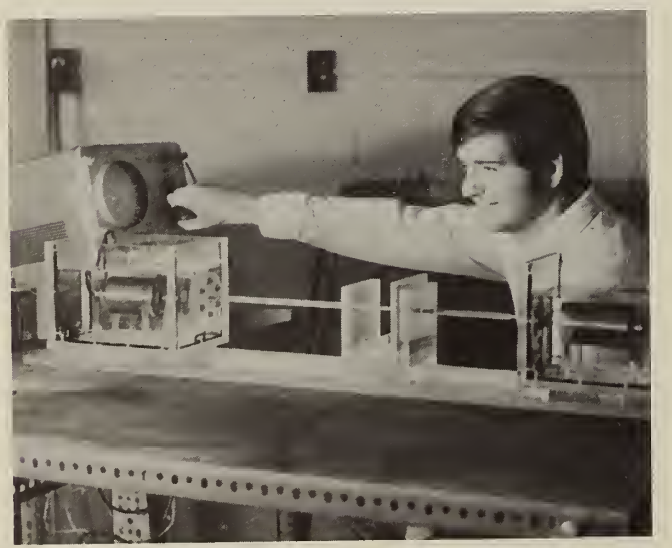
Research assistant John E. Koch adjusts the electrode spacing on the laboratory model of a carbon-oxygen fuel cell.

Because a fuel cell has high efficiency and does not require water for cooling, thermal pollution is essentially eliminated. It is hoped that the research will result in the development of a cool-air fuel cell capable of producing large quantities of electric power. ◆

UNDERGRADUATE RESEARCH IN ENGINEERING MECHANICS

A recent grant from the National Science Foundation has enabled the Department of Theoretical and Applied Mechanics to expand its undergraduate research program, under the direction of Professor Joseph P. Gallagher, to a full calendar year. The present program for senior students of engineering mechanics provides two courses, oriented toward research and development, during the academic year. The grant of $5,100 will support an additional three months of independent study for five undergraduates who have demonstrated ability and competence for research.

The undergraduate research program is designed to develop the students' intellectual curiosity and creativity by allowing them to direct their own work and to assume responsibility for their accomplishments. Students are permitted to select, develop, execute, and evaluate an experimental or analytical investigation of any phase of engineering science. Some undergraduates have undertaken theoretical research that involves mathematical descriptions of fluid flow, the properties of materials, or the vibration and stress characteristics of structures, while others have done experimental work that has included the development of new equipment and instrumentation for the interpretation and correlation of experimental data with existing theories.



Terry Raszhart, a graduate student in the Department of Theoretical and Applied Mechanics, is demonstrating the use of ultrasonic waves to detect flaws in a piece of fiberglass-reinforced epoxy material. As the sound wave is passed through the material, microvoids will cause perturbations in the transmitted signal displayed graphically on the oscilloscope. Raszhart began this research as part of the department's undergraduate research participation program.

Research is considered vitally important to the study of engineering mechanics, and the program has been created to give students who are capable of fine research the opportunity to discover and develop their talents under the guidance of senior staff members. Although the courses are intended specially to give students the best possible background for careers in research and development, the benefits to be gained from having the responsibility of directing and organizing independent work are not limited to students who enter research careers.

Candidates for the summer extension of the research program will be selected in April from the group of seniors currently enrolled in the second semester of the existing sequence of courses. Support for the students, supplemented by funds from the department, will amount to a stipend for each student of one hundred dollars per week for the twelve weeks of the summer. ◆

WATER, WATER EVERYWHERE

In preparation for research expected to be performed in the new Civil Engineering Hydrosystems Laboratory, four specially designed water-flow channels or flumes, all with variable slope, are being constructed for experimental simulation of the characteristics of water flow in river and stream beds. The laboratory will also be equipped with a water tunnel for the study of flow around submerged forms and a wind tunnel for research and instruction in the mechanics of fluid flow.

The largest of the laboratory's four water channels — 156 feet long, six feet wide, and four feet deep — can be set to any desired slope from zero to 2.5 percent. While the available range of slopes may seem small, the majority of natural riverbeds have grades which are only a fraction of 1 percent. This water channel will also be equipped with a wave generator and will have a sediment feed system at the upstream end.

The equipment to introduce sediment into the water flow is particularly important to the study of the transport of stream bed materials. The feed system for this water channel has an advantage over many existing systems in that the sediment is introduced by running the flow over a controlled sediment source on the bottom of the bed. Most systems simply dust the appropriate amounts of sediment from an overhead feeder into the flow.

The second largest of the channels will be a special purpose, closed-loop system which recirculates the water it uses and which is being constructed of special materials to prevent contamination of the water during its circulation. This flow channel, intended for the study of the behavior of biological organisms in stream water, will have a 140-foot open bed lined with fiberglass, polyvinyl chloride plastic pipe for the return of the water, and a stainless steel circulating pump. Most other metals and even many other plastics would be unsuitable in the construction of this flume since they would lead to chemical contamination of the water.

The remaining two channels are 64 and 30 feet in length and have adjustable slope. The longer of the two channels, with a 2-foot-wide bed, can be tilted to an unusually high 10 percent slope. The extreme angle permits the study of "slug flow" or roll waves characteristic of certain steep, shallow flow systems.

In addition to the flow channels, the laboratory will also be equipped with a German-made water tunnel. Operating on very much the same principle as a wind tunnel, the water tunnel can be used to study flow around such things as hydrofoil structures or the hulls of submarines. The pressure on the water in this tunnel can be varied from a relatively high vacuum to about twice atmospheric pressure.

The Hydrosystems Laboratory is located north of the present Civil Engineering Building. The new building contains office space for hydrosystems engineering, the University Water Resources Center, and other study and research activities related to water. Occupation of the building began in January 1970. The current research programs and facilities, with the exception of the Watershed Experimentation System (*Outlook,* October 1968), are being moved to the new laboratory. Major areas of research include hydrology, hydromechanics, hydraulic structures, ocean engineering, and water resources. ◆

ENGINEERING: HOW IT WAS, HOW IT IS

Some of the best-known engineers and engineering projects of the University's first century are the subjects of a book, *Men and Ideas in Engineering,* published by the University of Illinois Press for the College of Engineering. A well-illustrated, readable book that focuses as sharply on ideas and people as on the technical aspects of machines, *Men and Ideas* relates a dozen stories that range from finding a cure for railway "rail cancer" to the invention of the betatron, from pioneering the use of ultra-high-frequency sound for mapping the brain to the creation of the ILLIAC series of computers.

The change shown in engineering research and education over Illinois' first century reflects many of the changes in engineering generally: an increasing emphasis on a scientific approach, rather than "cut and try," and an increasing influence and interaction with the values and economy of the rest of society. In the book's pages the dual pictures of an engineering professor as an ivory-tower hermit or "grease monkey" merge with time into a figure called upon to emphasize basic scientific principles in his teaching, engage in more and more esoteric research, and at the same time play the sometimes earthy games called "Publish or Perish," and "While You're Up, Get Me a Grant."

More than the story of one school's accomplishments, the book uses its "men behind the machines" point of view to convey the excitement and the misfortune, ignorance, and bureaucratic indifference which affect the engineer as much as they do anyone else. *Men and Ideas,* by showing both the genius and the fallibility of the engineer, refutes the misconceptions which surround him, suggesting instead respect and caution for him as an ordinary fellow in an extraordinary influential line of work.

The book, written by Elisabeth Schillinger, Rudy Berg, and Alan Kingery, is available at $5.00 (plus 5 percent state tax for Illinois residents) from the University of Illinois Press, Urbana, Illinois 61801. ◆

MONEY MONEY MONEY MONEY

Grants and awards totaling $85,750 have been made to the University of Illinois at Urbana-Champaign as part of the educational aid programs of two large corporations.

From the Du Pont Company, academic grants, designed to finance work which otherwise would not be possible and to maintain or enhance excellence in teaching and research, were $20,000 for chemistry, $10,000 for chemical engineering, and $5,000 each for mechanical engineering and physics. The $20,000 young faculty award from Du Pont supports gifted faculty in chemistry beginning teaching and careers in highly original research.

Secondly, the Eastman Kodak Company has made grants, each for $10,000, to the Department of Chemistry and Chemical Engineering and for physics research in the Coordinated Science Laboratory. The University also received a direct grant of $5,750 in the first year that Kodak has included publicly supported colleges and universities in this phase of its educational aid program. The total of $25,750 brings to $190,750 given to the University by the company since 1962. ◆

BETA THAN EVER

In 1950, the world's most powerful betatron, a circular apparatus for accelerating electrons to high energies, was completed at the University of Illinois at Urbana-Champaign. The big machine, weighing 400 tons, has been used for research in high energy physics for nearly twenty years. Capable of producing electron energies of 340 million electron-volts to probe atomic nuclei, the betatron has been made obsolete by newer and more powerful machines and will soon be dismantled.

The betatron will be replaced by a new linear accelerator coupled to a racetrack microtron for recycling the electrons. The output of the new system will be a 600-million electron-volt beam of electrons. The continuous beam, with its duty factor of one hundred percent, contrasts greatly with the 0.1-percent duty factor of the betatron. In other words, the betatron could produce a beam of electrons in pulses for only one-tenth of 1 percent of the time it operated. The new linear accelerator (*Outlook*, September 1969) also will use superconductivity to overcome some of the difficulty of handling large electrical currents, and, like the betatron, it will be the first of its kind. ◆

PEOPLE AND PLACES

Professor of chemical engineering and of physical chemistry **Harry G. Drickamer** will be participating in the forthcoming NATO International Advanced Study Institute on High Pressure Physics to be held at the Delft University of Technology in The Netherlands. The topic of his presentation will be electron transfer and chemical processes. Professor Drickamer is also a member of the Advisory Committee of the institute.

Professor **C. Dale Greffe** of the Department of Mechanical and Industrial Engineering has been elected chairman of the Illinois Professional Engineering Examining Committee. Appointed a member of the nine-man committee last September by Governor Richard B. Ogilvie, he was elected its chairman by his fellow members. The purpose of the committee is to administer the state's professional engineering registration act.

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ENGINEERING OUTLOOK

at the University of Illinois at Urbana-Champaign

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UNIVERSITY OF ILLINOIS BULLETIN · COLLEGE OF ENGINEERING · VOL. 11, NO. 8, APRIL 1970

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AT URBANA-CHAMPAIGN

In the order listed, this issue contains articles on the following subjects:

INSTITUTE ON "THE MAN-MADE WORLD"
ENVIRONMENTAL CRISIS WEEK
COURT OF APPEALS DECISION
RESEARCH IN PROCESSING NUCLEAR FUELS

THE MAN-MADE WORLD

Thirty high school teachers from across the United States will be at the University of Illinois at Urbana-Champaign from June 29 to August 7 for the second annual, six-week summer institute exploring a new engineering course intended for high school students and entitled "The Man-Made World." The course, oriented toward laboratory work, was developed as part of the Engineering Concepts Curriculum Project of the Commission on Education (formerly the Commission on Engineering Education) of the National Academy of Engineers.

The course was created because revisions in high school science curricula have increased stress on more abstract concepts without increasing the attractiveness of the basic sciences. For high school students who intend to become lawyers, accountants, or similarly nontechnical professionals — those students who normally do not register for basic science courses — the major contact with the basic sciences will come essentially through encounters with technological applications. The high school course stresses scientific principles, considers the profound impact of technology on "the man-made world," and is designed to encourage the development of a realistic attitude toward technological change.

The teachers participating in the institute will study systems engineering, including feedback and stability, and analog and digital computers. Since part of the course material will be presented with the PLATO system (*Outlook,* January 1970), the high school teachers will also gain first-hand experience with computer-based education. In addition, they will use and build electronic equipment to demonstrate and test the concepts discussed in the course.

Professor Donald L. Bitzer, director of the Computer-based Education Research Laboratory, and Dominic O. Skaperdas, associate director of the laboratory, will be in charge of the institute supported by $37,633 from the National Science Foundation. ◆

ENVIRONMENTAL CRISIS WEEK

The College of Engineering, the College of Agriculture, the School of Life Sciences, and the State Natural History Survey joined in the sponsorship of the program Thursday afternoon, April 23, of Environmental Crisis Week at the University of Illinois. The activities of the week, which actually extended over two full weeks, were organized as part of the national effort toward a teach-in on the environment initiated by Senator Gaylord Nelson of Wisconsin.

The afternoon program included two sessions on the condition of the environment and enlisted the aid of both University and visiting speakers. The first session, "Science and Our Society: The Ecological Challenge," presented two speakers who gave a general introduction to the four meetings to follow under the general title of "Maintaining Our Eco-System." Each of the meetings dealt with the present status and future possibilities of four major categories of resources — land, air, water, and food — and included speeches and panel discussions on selected topics of importance. ◆

OOPS!

In our article "Darkness At Noon, Almost" in the February issue, we referred to the facilities at a marine station at Turkey Point, Florida, as belonging to the University of Florida. The facilities are the property of Florida State University. ◆

THE WINNER . . . AND STILL CHAMPION

The University of Illinois Foundation recently announced that the United States Seventh Circuit Court of Appeals has upheld the foundation's patent rights covering types of log-periodic antennas developed at the University of Illinois at Urbana-Champaign. The court decision reaffirms a 1968 ruling by U. S. District Court Judge Julius J. Hoffman which held that the patent had been infringed upon by Blonder-Tongue Laboratories, Incorporated, of Newark, New Jersey, and enjoined them from further infringement.

The log-periodic antennas were developed by Dwight E. Isbell at the University's Antenna Research Laboratory. The design permits use of a single antenna over a wide range of radio frequencies. One such antenna can provide television reception on any channel in the VHF (channels 2–13) and UHF (channels 14–82) range, and can replace the two antennas that previously might have been required.

Through the U. of I. Foundation and its licensing agent, University Patents, Incorporated, of Chicago, the antennas have been produced and sold by JFD Electronics Corporation, a New York company, under a nonexclusive license agreement. ◆

PU

Uranium oxide, plutonium oxide, thorium oxide, and combinations of these expensive, radioactive ceramic materials are common nuclear reactor fuels. Nuclear engineers have had little choice except to use them, and researchers at the University of Illinois at Urbana-Champaign are examining methods to ease the handling of these materials.

Continuing his research begun at Argonne National Laboratory, Clauer T. de Freitas, a research fellow in ceramic engineering, has begun evaluating a new technique which he helped to develop for processing uranium and plutonium fuels. The technique, called pressure sintering, is being studied with the help of the University's scanning electron microscope. Professor Alfred W. Allen of the Department of Ceramic Engineering is assisting in an examination of the microstructure of some pellets of spent material (not containing plutonium) to get a better idea of the adequacy of the new production method.

The previous work by de Freitas at Argonne was devoted to the development of the production process and the construction of special furnaces and associated pressure equipment. The results of the research have been promising enough that construction of more furnaces based on the Argonne prototypes has already begun.

Before it can be placed in a typical power reactor, an oxide fuel mixture must be formed into pellets, and then these pellets must be machined to fit the rods that hold fuel in the reactor core. The machining process has to be performed in an isolation chamber or "glove box," and any waste powder created by grinding the pellets must be disposed of or recycled. Because of its dangerous radioactivity, absolutely no fuel must be lost during processing.

The process of pressure sintering also begins with a powder mix of the appropriate fuels. The term "sintering" traditionally means the strengthening and densifying of a material by the application of heat, and the new method employs both heat and pressure to form the fuel powder into a pellet with the required finished dimensions and hopefully with less need for further machining. The application of pressure also lessens the amount of heat required and permits the construction of smaller furnaces. The price of compactness, however, has been stringent requirements on the materials used in furnace construction, including special graphite dies for forming the fuel pellets and platinum-rhodium wire for the heating elements. Nevertheless, the cost of the fuel pellets from this process could be competitive with the cost of presently available fuels, and the process has already received some attention from industry.

The research work is being supported by the Atomic Energy Commission, and de Freitas' fellowship was provided by the International Atomic Energy Agency. With ten years of nuclear engineering experience in Brazil, de Freitas will be returning there for ten months beginning in August to assist in the development of a zero-power reactor facility. After completing his doctoral work, he will become responsible for the design of a nuclear reactor fuel production facility that will be the first of its kind in Brazil. ◆

HUZZAHS, KUDOS, AND THE LIKE

Five undergraduates and five faculty members of the College of Engineering will receive special recognition at the annual Engineering Honors Convocation on May 1.

The Everitt Undergraduate Teaching Excellence awards will be presented to Associate Professor Carl J. Alstetter of the Department of Metallurgy and Mining Engineering, Associate Professor Allan G. Friederich of the Department of Mechanical and Industrial Engineering, Associate Professor B. Jack Butler of the Department of Agricultural Engineering, and Assistant Professor Bruce M. Hannon of the Department of General Engineering. The awards, named after William L. Everitt, dean emeritus of the College of Engineering, were established and first presented in 1968. The recipients are selected through a survey of undergraduate engineering students.

The second annual Stanley H. Pierce awards will be presented to Professor Charles A. Wert, Head of the Department of Metallurgy and Mining Engineering, and to Robert J. Gustafson, senior in agricultural engineering. The Pierce awards are presented to one student and one faculty member in recognition of outstanding efforts to improve student-faculty cooperation.

The remaining four students are receiving special awards of a somewhat different nature. The Hamilton Watch Company Award is to be presented to Charles H. Ludmer, a senior in electrical engineering, as the senior in engineering who has most successfully combined proficiency in his major field with notable achievements in the social sciences and humanities. David R. Lancaster, a junior in mechanical engineering, will receive the Honeywell Award for distinguished performance and leadership; Charles L. Schaidle, a senior in mechanical engineering, will receive the Harvey H. Jordan Award for scholastic standing and character; and Paul S. Litherland will receive the Lisle Abbott Rose Memorial Award for technical excellence combined with cultural breadth, depth, and sensitivity. The four students receiving special awards have all maintained fine academic records while participating in numerous University activities and extracurricular academic endeavors. ◆

CONSTRUCTION RESEARCH SERIES — NUMBER 13

The thirteenth of a series of papers relating to construction research in the Department of Civil Engineering has been published by the Engineering Publications Office. Entitled "Production of Multi-Level Critical Path Method Networks," the paper deals with the employment of the critical path method (CPM) to assist construction managers in the planning and scheduling of work. In particular, it seeks to develop processes for the generation, organization, and presentation of CPM networks so that the several levels of management in a construction company can effectively and efficiently use the process and the results.

This report was prepared by Vernon J. Eardley, research assistant in civil engineering. The work was done under the immediate supervision of Dr. E. L. Murphree, Jr., Assistant Professor of Civil Engineering, who is listed as co-author of the paper. The report is available for $3.00 from the Engineering Publications Office, University of Illinois, 112 Engineering Hall, Urbana, Illinois 61801. ◆

THE THUNDERING HERDS

A nationwide survey of 269 engineering schools has shown that the University of Illinois at Urbana-Champaign is second only to Purdue University in the number of bachelor's degrees granted and in the total number of engineering degrees granted at all levels. Purdue University awarded 888 bachelor's degrees and 1,375 degrees of all types during the last year, exceeding this University's totals of 733 and 1,186, respectively. The survey, conducted by the Engineering Manpower Commission, showed that the top three schools in either category are in the Big Ten conference.

The commission also reported national totals of 39,972 engineering bachelor's degrees, 14,938 master's degrees, and 3,387 doctor's degrees conferred. Although the total for bachelor's degrees was up nearly 2,000 over the 38,002 of 1968, it was well under the peak of 52,732 for 1950, and the commission has estimated that, through 1973, the number of bachelor's degrees will show a decline. In addition, the master's degree total, 200 short of last year's 15,152, ended seventeen years of continuous growth. Engineering doctor's degrees, however, were at an all time high, topping last year's total of 2,933. ◆

PEOPLE AND PLACES

The National Science Foundation has granted an additional $338,900 to the University of Illinois at Urbana-Champaign for the construction of the new linear accelerator (*Outlook,* September 1969). This most recent grant brings the total amount of NSF support for the project to over one million dollars.

Professor **Richard S. Engelbrecht** of the Department of Civil Engineering has been elected chairman of the Illinois Section of the American Water Works Association. Professor Engelbrecht had served as vice-chairman during the past year. The purpose of the AWWA is to advance and disseminate knowledge related to the design, construction, operation, and management of water supply facilities. The Illinois Section, with its 1,100 members, is one of the largest AWWA state organizations.

Professor Herbert E. Carter, Vice-Chancellor for Academic Affairs for the University of Illinois at Urbana-Champaign, has appointed Professor **Benjamin B. Ewing** of the Department of Civil Engineering as the chairman of the newly formed environmental sciences committee. The committee, composed of fourteen members from many of the colleges of the University, will consider how to organize most effectively teaching, research, and public service relating to the environment. It will also consider the need for a permanent organizational unit for environmental science and the relation of that unit within the structure of the University and to the three state scientific surveys — water, geology, and natural history — that are located on the University campus at Urbana-Champaign. The committee's report to Vice-Chancellor Carter is expected by the end of the current semester. According to Carter, the report should contain recommendations for action "to marshal most effectively the intellectual and other resources of the university to make the greatest possible contribution to complex problems of environmental quality control." ◆

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In the order listed, this issue contains articles on the following subjects:

RESEARCH IN SOLID STATE PHYSICS
AIRFOIL DESIGN
RETIREMENT OF GERALD M. ALMY
ACOUSTICAL TESTING

SOLID, MAN!

Undertaking the task of studying the properties of solids at room temperature is overwhelming, but when the study is conducted at temperatures ranging from the supercold of solid helium and at pressures approaching 10,000 atmospheres, it is almost impossible to know where to begin. Professor David Lazarus of the Department of Physics and his associates in the Materials Research Laboratory have already chosen a place to start and have been making some interesting discoveries through a research program that has been continuing for about twenty years.

The researchers chose pressure as the independent variable for most of the experiments because very little previous work had been done to examine the effects of its variation on the properties of solids. Pressure and temperature are the two so-called "extensive" properties of materials because, under equilibrium conditions, they are independent of the size or extent of the material or any part of it. Since temperature is much easier to vary, the effects of its variations under constant pressure have been studied much more frequently.

The purpose of the high uniform pressure is to force a change in the interatomic distances within the solid structure. Pronounced effects on crystal lattice defects and diffusion characteristics, electronic transport phenomena, paramagnetism, and phonon transport in heat transfer are among the more important changes that take place.

The diffusion of atoms through a solid occurs predominantly by movement through vacancies in the lattice and through interstitial spaces, with the former mechanism being much more important. The current research is exploring the nature of vacancies in metal crystals and in crystals of alkali halides. In an alkali halide such as sodium chloride (table salt), the bonds between adjacent atoms in the crystal lattice are the result of electrostatic attraction. Each sodium atom has become ionized through the loss of an electron and therefore exhibits a positive charge. Each chlorine atom has acquired an extra electron and exhibits a negative charge, and the opposites attract to hold the crystal together.

If an atom is missing from its appropriate place in the lattice, the charges surrounding it are no longer neutralized and repel each other causing the lattice to deform. Farther away, atoms of the same kind as the one that is missing see a region of strong opposite charge and are attracted to it causing further lattice deformation. The usual assumption has been that the volume of the vacancy is approximately the volume of the missing atom and expected diffusion properties have been calculated accordingly. The results of this research have shown that the vacancy resulting from a missing atom is actually much smaller than one atomic volume. Such a determination has a correspondingly profound effect on calculations of diffusion characteristics.

Some of the electronic properties that have been studied involve charge transport, the shapes of Fermi surfaces describing electron energy levels, thermoelectric power, and electrical resistance. Certain experiments have been able to verify a recent theoretical development for calculating the shape of Fermi surfaces, the "pseudopotential model," by changing the interatomic distances in aluminum and comparing the predictions with the observations. Thermoelectric power, the kind of power generated by a thermocouple, depends on the curvature of the Fermi surface, and its determination is a corollary result of the calculation of the surface shape.

Perhaps the most intriguing of the experiments has been the study of phonon transport in solid helium. Phonons are quanta of acoustical energy very much like photons are quanta of electromagnetic energy. As the word "acoustical" implies, phonons represent discrete amounts of vibrational energy transferred from one atom of a lattice to another. Heat transfer through a lattice is accomplished, on an atomic scale, by phonon transport.

Solid helium (helium IV) has been found to be by far the most compressible solid known to man. Its compressibility permits study of a wide range of interatomic distances over a relatively small range of pressures, and the properties it demonstrates should serve as a good model for the solid state of other inert elements. ◆

WHAT GOES UP

Research conducted during the preparation of a doctoral thesis by Robert H. Liebeck has led to the design of a new class of high-lift, low-drag airfoils. The work, conducted under the supervision of Professor Allen I. Ormsbee, involved a theoretical study of changes in lift as a function of changes in the cross-sectional shape of an airfoil. The mathematical modeling of the airfoil characteristics was done, as Professor Ormsbee put it, using conventional boundary layer theory and the calculus of variations. The calculations were performed on a digital computer.

It is a characteristic of airfoils that the angular position from front to back with respect to the horizontal has a pronounced effect on the amount of lift the airfoils provide. As the angle is increased, the lift increases at first, reaches a peak, at which point the airfoil is said to be "stalled," and then decreases. The object of the research was to raise the maximum amount of available lift by altering the airfoil shape. The mathematical simulation shows an increase in lift on the order of 20 to 70 percent over conventional airfoils, and, by a happy coincidence, the airfoil shape developed has pleasingly low drag.

Another condition involved in airfoil design is the airfoil's ability to perform well over a wide range of speeds. The usual procedure for satisfying this requirement has been the selection of a conventional airfoil with good high-speed characteristics followed by the determination of ways to improve low-speed characteristics through movable flaps and slats. By sacrificing high-speed performance, however, low speeds can be accommodated more easily. Liebeck's research has been conducted on the assumption that the high-lift airfoils will be of most service to STOL (short take-off and landing) aircraft which normally cruise at speeds of 200 to 400 miles per hour.

Although Liebeck's work has been completed, further study of the airfoil development is being undertaken as part of a continuing research program supported by NASA. Allen W. Chen, another advanced graduate student whose research is being supervised by Professor Ormsbee, is extending Liebeck's work by studying a theoretical model of two airfoils flown close together simulating a conventional flapped wing. The object of this study is to determine if a configuration may be found which has both good low-speed characteristics and, by altering the relative position of the two airfoils, good high-speed characteristics. ◆

ALMY MATER

In 1930, Gerald M. Almy came to the University of Illinois as an instructor for the Department of Physics. He served as acting head of the department in 1951-52, as associate head after 1952, and as head of the department from 1964 until his retirement this year.

The thirties were to see a major change in his and the department's research interests away from spectroscopy toward nuclear physics. In 1936, Dr. P. Gerald Kruger, who is also retiring this year, built a cyclotron, the second in operation anywhere. By 1940, Dr. Donald Kerst had invented the betatron, and nuclear physics had become the major field of physical research at Illinois. The research has been expanded and continued with the very high energy accelerators at Argonne and other national laboratories.

During World War II, Dr. Almy assisted in the development of the betatron for radiography of metal structures, and took charge of the project when Dr. Kerst left for other research. After the war, he continued in nuclear research with the betatron until 1951 when his duties as departmental administrator began.

In 1949, Professor Fred Seitz joined the department. He soon was followed by professors Bardeen, Koehler, Lazarus, Mapother, Maurer, and Slichter, and the field of solid state physics was both introduced and firmly established. The expansion of research in solid state physics has been the major development during Dr. Almy's term as associate head and head of the Department of Physics. In terms of numbers of graduate students and faculty members, solid state physics is presently the largest division of the department.

During this period, the Department of Physics also had a great deal to do with the establishment of both the Materials Research Laboratory, in which it is one of the five participating departments, and with the Coordinated Science Laboratory. In CSL, students from the Department of Physics can engage in research in cooperation with other departments in the fields of surface and plasma physics. MRL houses much of the research on solid state and low temperature physics by the department's faculty members and students.

The Department of Physics at the University of Illinois at Urbana-Champaign is in the unusual position of being part of the College of Engineering because, historically, the first professor of engineering felt that a strong physics background was essential to a thorough engineering education and sought to develop the source for that background within the college. Since then, innumerable engineering freshmen have locked horns with the department and will continue to do so in the foreseeable future.

To the man who has been a part of more than one third of the history of the department, we say thanks and wish that his successor might do as well. ◆

A LOT OF NOISE

Just like opera singers who can shatter cut crystal, an electronic apparatus used by Professor Adam Zak of the Department of Aeronautical and Astronautical Engineering can split structural models of stiffened aircraft panels. Enclosed in a soundproof room, the apparatus consists of a high-powered sound generator and a suspension mount for the panel under test.

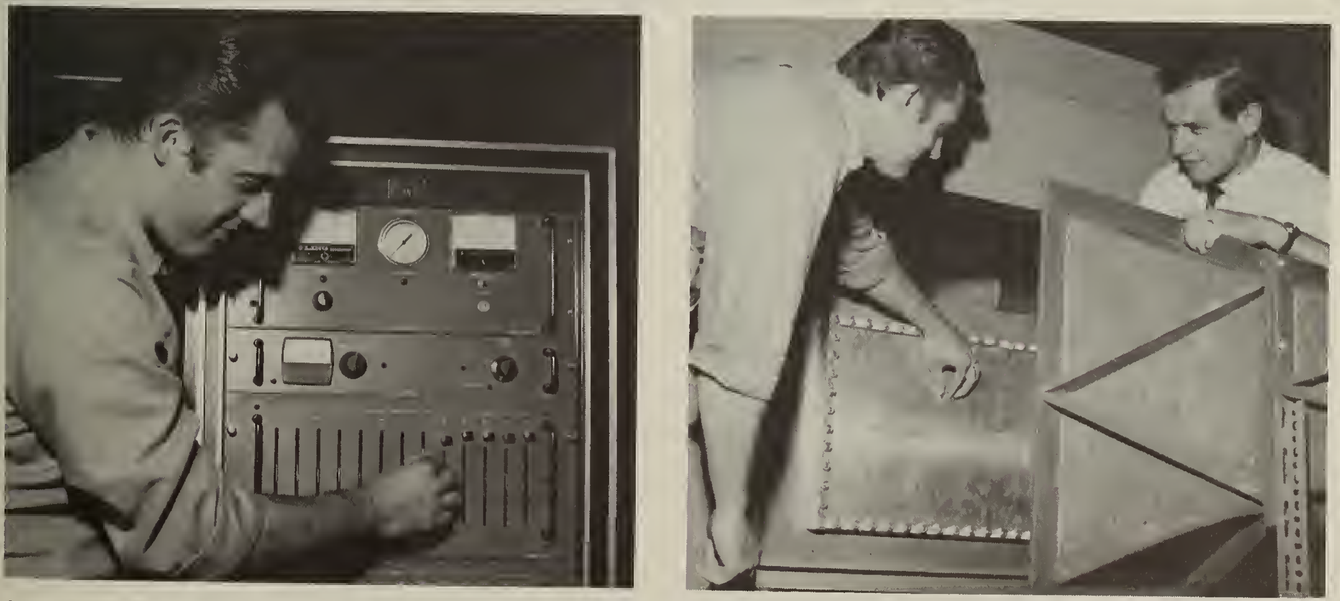
The purpose of the concentrated noise is to simulate real conditions on structural sections of airplanes and missiles. Aerodynamic turbulence and the tremendous noise of jet or rocket engines create structural vibrations that, at appropriate frequencies and power levels, can tear the vehicles apart.

The acoustic energy from the generator is directed against the surface of the test specimen by a large fiberglass horn. The system is capable of producing up to 150 decibels of sound power — about 1,000 times the noise level in the cabin of a jet airliner — over a frequency range from 100 to about 650 cycles per second.

The sound system creates what Professor Zak calls "shaped noise" to test the panels. Attenuators at specific frequencies over the available range control a random electrical noise signal. This signal, in turn, controls a valve in the acoustical noise generator. Compressed air is driven past the valve, and its fluctuations produce acoustical energy at the appropriate frequencies.

A spectrum analyzer is being used with the test system to monitor the output of the noise generator and the vibrational response of the stiffened panel. Monitoring of the power spectrum of the sound output is accomplished by observing the electrical noise signal, but checking the response of the panel requires considerably more sophisticated techniques since monitoring equipment cannot be allowed to interfere with the panel's free movement. To satisfy this requirement, a tiny piezoelectric accelerometer, weighing only 1/2 gram, is attached to the panel surface. The tiny instrument is capable of monitoring acceleration up to 150 times that of gravity, and the acceleration recorded can be converted to panel displacement.

Subjecting characteristic models of flight vehicle panels to these and other tests can give important information about structural changes and reinforcements needed to prevent vibration damage. ◆



Graduate student Ed Wagulis is shown (left) making adjustments to the attenuators controlling audio frequencies in the noise signal to an acoustic generator. The sound from the generator is used to test the vibrational characteristics of aircraft panels. The response of a panel is monitored by a tiny accelerometer (right, center of picture) being attached to the panel surface by Ed Wagulis under the watchful eye of Professor Zak.

PEOPLE AND PLACES

The 1970 Western Electric Award for Excellence in Engineering Instruction has been presented to Professor **Wilbert F. Stoecker** of the Department of Mechanical and Industrial Engineering. Two professors from the engineering colleges in Illinois and Indiana were selected to receive the award which was presented at the Illinois-Indiana Section meeting of the American Society for Engineering Education held on April 25 at Notre Dame University.

David S. Lieberman, Professor of Metallurgy at the University of Illinois at Urbana-Champaign, presented one of the eleven invited lectures by scientists from all over the world at a special symposium on "X-ray Analysis — Past, Present, and Future" held at the Royal Institution in London in celebration of the eightieth birthday of Sir William Lawrence Bragg, Nobel laureate in physics.

The first **T. A. Read Memorial Lecture,** honoring the man who headed the Department of Metallurgy and Mining Engineering for thirteen years before his death in 1966, was presented on April 30. The speaker was a world-famous metallurgist, Professor Cyril S. Smith, of the Department of Humanities of the Massachusetts Institute of Technology. Professor Smith discussed "Art and Science in the History of Metallurgy." The lecture was sponsored by the T. A. Read Memorial Lectureship Fund of the University of Illinois Foundation. ◆

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WORLD'S SECOND CHEMICAL LASER
SHORT COURSE IN RUNWAY DESIGN
HEATING RESEARCH
NEW MATERIALS TESTER FOR CIVIL ENGINEERING

SOMETHING NEW

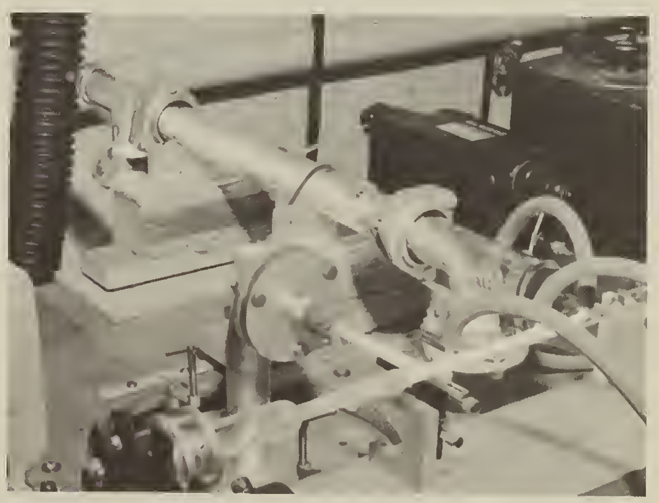
The world's second chemical laser system has been developed in the Electrophysics Laboratory of the University of Illinois at Urbana-Champaign. Under the supervision of Paul D. Coleman, Professor of Electrical Engineering and director of the laboratory, research assistant Curt Wittig developed the system in which a chemical reaction creates molecules in energy levels above the ground state. The electromagnetic laser radiation at a wavelength of approximately 5 microns is produced continuously as long as the chemical reaction proceeds.

Exploiting an extremely fast two-step chemical reaction between atomic oxygen (O) and carbon disulphide (CS_2) yielding carbon monoxide (CO), the laser action is the result of vibrational energy state transitions of the carbon monoxide molecule. The reaction is capable of releasing about 10,000,000 joules of energy per pound of fuel, and Professor Coleman believes as much as 60 percent of it can be collected in the pumped CO molecules. With a fuel consumption rate of one pound per second, such a laser would constitute a continuous source of six megawatts of electromagnetic power.

To study the reaction in the laboratory, the experimental apparatus consumes only 1 pint of fuel per week to produce about a watt of power. As Professor Coleman has stated, "To study the chemistry and laser physics of the problem requires only a modest apparatus." The combustion flame of the reaction is confined in a typical mirrored laser system and behaves as a sort of chemical engine with no moving parts for the conversion of chemical potential energy into electromagnetic energy.

Although the chemical reaction in the present system takes place at low pressure requiring a pump to remove exhaust gases, Professor Coleman is optimistic about operation at higher pressures. The laser is a self-contained, entirely chemical system except for the electrical discharge apparatus creating the atomic oxygen. Since the primary reaction is so rapid — about 20 to 30 microseconds for both steps — a comparably fast chemical reaction generating atomic oxygen will have to be found before the system can be made entirely chemical.

Professor Coleman plans to continue study of the chemical system to get a better understanding of its behavior, and he does not anticipate attempting to scale it up to a larger size. The laser reaction gives a valuable opportunity to study where the energy released in a chemical reaction goes into the resulting molecules. The nature of the emission spectrum should yield more detailed information, unavailable through ordinary chemical methods, about excitation of the rotational and vibrational energy states in the CO molecule. ◆



The blue flame of burning sulphur, a by-product of the principal reaction in the world's second chemical laser system, is used to monitor the reaction's progress. The laser system was developed in the Electrophysics Laboratory of the University of Illinois at Urbana-Champaign.

BETTER RUNWAYS FOR BIGGER IRON BIRDS

The rapidly increasing gross weights of contemporary aircraft have motivated engineers to question the validity of design procedures for airport pavement. To inform engineers about the latest trends in pavement design and to examine their value, and to help engineers select the best practices and procedures for their particular needs, the University of Illinois Department of Civil Engineering in cooperation with Construction Engineering Research Laboratory of the U.S. Army Corps of Engineers and the Airport Operators Council International are sponsoring a short course entitled "Structural Design of Airport Pavements."

Practicing engineers and engineers from the academic world will discuss the critical properties of pavement systems and the materials and methods of pavement construction and will incorporate consideration of them into the development of the design process. The economics of construction will be stressed throughout the course. Participants in the course also will have the opportunity to work on an actual design problem using the systems approach that will be developed.

The fee for the course is $250. It will be offered September 21–25. Further information is available by writing Dr. E. J. Barenberg, 111 Talbot Laboratory or Dr. M. K. Blanchard, Coordinator of University-Industry Relations, 202 Engineering Hall at the University of Illinois, Urbana, Illinois 61801 or by phoning (area code 217) 333-6252 or 333-3836, respectively. ◆

ENGINEERING WARMTH

Nearly half a century of research into the heating of typically furnished homes built for the purpose is ending this summer at the University of Illinois at Urbana-Champaign. The results of the research, sponsored by industry, in these special houses have made many new homes more comfortable and made their heating more economical. Although studies will no longer be conducted in houses, the Department of Mechanical and Industrial Engineering will continue its laboratory work on related aspects of environmental control.

Professor Arthur Cutts Willard, who later became president of the University, began heating research on this campus in 1916. Eight years later, the National Warm Air Heating and Air Conditioning Association sponsored construction of the world's first research house. As house styles and sizes changed, the first house was successively replaced by three others, the last of which was sold in 1954. By 1940, however, the competing Institute of Boiler and Radiator Manufacturers had built their first house which they replaced in 1958 with the one now being closed out.

Coincident with the closing of the house is the retirement of Professor Warren S. Harris, who has been associated from the beginning with the research sponsored by I-B-R. His major contributions have been the development of the baseboard radiator and of testing procedures for radiator and convector performance.

The baseboard radiator, perhaps better known as the "radiant baseboard," was tested first in a University laboratory then installed in the rooms of the I-B-R research home during the winter beginning in 1943. The idea of baseboard heating pipes was inspired by their use in railroad passenger cars, and the success of the tests in the research house prompted the I-B-R research committee to recommend their use in private homes. The response from industry was immediate, and radiant baseboards presently are installed in almost all new homes using hot water heat.

Professor Harris was part of a research group that achieved world-wide fame. In addition to Willard and Harris, the group included Professors Kratz, Fahnestock, Severns, Fellows, and Konzo, who is presently associate head of the Department of Mechanical and Industrial Engineering. Under the sponsorship of heating industry associations, these men carried on work which changed home heating from rule-of-thumb guessing to sound engineering practice. ◆

A NEW TOY FOR THE KIDS

When buildings, bridges, and highways are put together, there are a lot of parts that get pushed and pulled around. In an effort to determine just how much these parts are going to take, the Department of Civil Engineering has acquired a highly sophisticated materials-testing machine from MTS Corporation. According to Professor James E. Stallmeyer, the new machine is, "in the aggregate, the largest machine MTS has built." While it is not as powerful as some testing machines since it can only exert 600,000 pounds of static load pressure or 400,000 pounds as a repeated load, the machine can accommodate between its columns a specimen that is 12 feet high and 4.5 feet wide. In addition, supports built into the floor of the building and extending from two sides of the machine allow mounting of beam specimens up to 22 feet long.

The testing machine is housed in the hollow core of the recently enlarged Civil Engineering Building and is connected to the building's very versatile high-pressure (3,000 psi) hydraulic system. The system includes two pumps each with a 70-gallon-per-minute capacity and a smaller pump with a 20-gallon-per-minute capacity. One of the larger pumps is intended primarily to serve the new tester, while the other pumps serve the earthquake simulator (*Outlook,* October 1966), the Concrete Laboratory, two locations in the Models Laboratory, and anything else that may need to be connected to an hydraulic supply. Each portion of the system can be isolated from every other portion; as long as the total fluid requirement does not exceed the 160-gallon-per-minute capacity, the testing experiments will not interfere with each other.

The materials tester itself has some interesting capabilities. Following an electronically generated ramp, sawtooth, sine, or truncated sawtooth function, an arbitrary function drawn on a foil-covered drum called a Data-Trak, or field data recorded on a magnetic tape, the tester can servomechanically control the pressure or tension of the ram (the part of the machine in motion during testing), the strain of the specimen, or the position and speed of the ram to within amazingly fine tolerances over several ranges of pressure or tension. If a specimen is to be heated to study its thermal expansion, the ram position can be hydraulically controlled to within 0.0005 inches. The pressure or tension exerted is never inaccurate by more than .5 percent. No other piece of equipment having capabilities approaching those of the new testing machine is available on the Urbana-Champaign campus. The new machine opens the door for advanced and informative testing of all types of materials from steel structures and concrete samples to soil and rock samples and highway pavement materials. ◆

COMING TOGETHER

The College of Engineering, the College of Veterinary Medicine, and the School of Life Sciences of the Urbana-Champaign campus were represented at the University's first Bioengineering Workshop sponsored by the College of Engineering and held at Allerton House on May 17 and 18.

The principal aim of the workshop was to outline the many research projects on the campus that deal with bioengineering. In all, twenty-two brief technical presentations were made on subjects ranging from "Stress-Induced Biopotentials in Bone" to the "Automated Analysis and Processing of Speech Signals." The workshop proved to be a source of new research ideas and brought together several individuals who were previously unaware of each other's efforts. The wide variety of research fields represented at the workshop and the correspondingly wide assortment of technical languages emphasized the need for closer communication between the various research groups.

Wendell S. Williams, Professor of Physics and of Ceramic Engineering, was chairman of the Workshop Subcommittee of the College's Bioengineering Committee headed by Professor John C. Chato of the Department of Mechanical and Industrial Engineering. It is expected that the workshop, judged a success by its forty-eight participants, will lead to a more vigorous, better coordinated, and better focused effort in bioengineering on the Urbana-Champaign campus. ◆

SCHOOL FOR CHEMISTS

Establishment of a School of Chemical Sciences within the University of Illinois at Urbana-Champaign has been approved by the University's Board of Trustees and awaits approval by the State Board of Higher Education. The school, to be a part of the College of Liberal Arts and Sciences, would include as departments the divisions of chemistry, biochemistry, and chemical engineering that are presently within the single Department of Chemistry and Chemical Engineering.

Except during its earliest years, the department has always had some form of divisional structure. Three years ago, the areas of analytical, inorganic, organic, and physical chemistry were combined to form one of the present divisions. In the new School of Chemical Sciences, each of the three departments would continue having the advantage of close association with one another. The school, responsible for overall direction of the departments, would coordinate joint projects and be responsible for common facilities including the chemistry library, laboratories, shops, and storerooms. ◆

MONEY WHERE THE MOUTH IS

The Kaiser Aluminum and Chemical Corporation of Pleasanton, California has given $2,000 to the University of Illinois at Urbana-Champaign for grants to American minority-groups students interested in ceramic engineering. The University of Illinois houses one of the eighteen departments of ceramic engineering in this country. Professor Arthur L. Friedberg, head of the department, has announced that four $500 grants have been established for the 1970–71 academic year. ◆

PEOPLE AND PLACES

Professor **Rudolph A. Marcus** of the Department of Chemistry and Chemical Engineering of the University of Illinois became the eleventh chemist from the Urbana-Champaign campus elected to the National Academy of Sciences. A physical chemist specializing in chemical kinetics and the mechanics of chemical reactions, Professor Marcus is one of fifty members newly elected for their "distinguished and continuing achievements in original research." He is the twenty-first University faculty member among a total over the years of only 870 American scientists honored by selection to the academy.

Assistant professors **Christopher J. Pethick** and **Myron B. Salamon** of the Department of Physics and Associate Professor **William H. Pirkle** of the Department of

Chemistry and Chemical Engineering are among seventy-six young physical scientists from forty-three colleges and universities who have been awarded Alfred P. Sloan Foundation fellowships for basic research.

Assistant Professor **Frank A. Morrison, Jr.**, of the Department of Mechanical and Industrial Engineering has been named as next year's half-time Assistant Dean for the College of Engineering. The half-time position was established last year in the Office of the Associate Dean and was held first by Associate Professor Blake E. Cherrington of the Department of Electrical Engineering. The purpose of the appointment is to permit closer contact between the Office of the Associate Dean and the faculty members and students of the College. The faculty member selected to fill the position still retains half of his time to teach or to do research.

As part of the technical program of the Fourth Annual Biomechanics Conference, Professor **Cletus A. Bowman** of the Department of Theoretical and Applied Mechanics and **Marvin L. Janssen** from the Firestone Tire and Rubber Company of Akron, Ohio, presented a paper on "The Dynamic Reponse of Two-Dimensional Photoelastic Models of the Human Head" (*Outlook*, January 1969). The conference was sponsored by the Biomechanics and Human Factors Division of the American Society of Mechanical Engineers.

Professor **Nathan M. Newmark**, head of the Department of Civil Engineering, has been elected a fellow of the National Academy of Exact, Physical, and Natural Sciences of Argentina. The fellowship will be conferred in Buenos Aires on August 22 at a meeting of the academy. Professor Newmark is internationally known for his research and teaching in structural engineering and structural dynamics. A member of the National Academy of Science and of the American Academy of Arts and Sciences and a founding member of the National Academy of Engineering, Professor Newmark received the National Medal of Science in 1969 "for contributions to the advancement of engineering knowledge of structures subjected to earthquake or blast and for inspiration to others in improving man's environment." ◆

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 12, NO. 1, SEPTEMBER 1970

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In the order listed, this issue contains articles on the following subjects:

SUPERCONDUCTIVITY DISCOVERY
RESEARCH ON LEAD POLLUTION
HOLOGRAPHY AND A HIGH SCHOOL STUDENT
SYMPOSIUM ON CLOSE-RANGE PHOTOGRAMMETRY

THORIUM HYDRIDE — GREAT THTUFF

Although it's always nice to see theoretical predictions become physical experience, it's even nicer for the person who made the predictions. That is exactly how nicely a lot of hard work and careful study paid off for Professor Cameron B. Satterthwaite of the University of Illinois Materials Research Laboratory who happened to be working with the superconductivity of thorium hydride, an awesome-sounding subject in itself.

Superconductivity is really a combination of two physical properties. The one most commonly associated with it is the ability to conduct an electric current with no loss due to resistance. The other less well-known property is perfect diamagnetism or the ability of a superconductor to expel any internal magnetic fields. This latter characteristic distinguishes superconductors from perfect conductors, which are only theoretical substances and which are not at all diamagnetic.

About one and one-half years ago, a paper from Cornell University speculated on the properties of metallic hydrogen. Although the condition has never been achieved, hydrogen is thought to have a stable, metallic phase at suitable density and under pressure equivalent to about 500,000 atmospheres. From its position on the periodic table of the elements, metallic hydrogen should be first in the series of alkali metals, including sodium and potassium. Unlike these, however, it is expected to be capable of superconductivity.

Along somewhat similar lines, metal hydrides (compounds of metals with hydrides) have been known to exhibit the properties of alloys of two metals. Such compounds of the heavy metals exhibit metallic conductivity, and of these, thorium hydride has the most appealing properties for superconductivity experiments. It is possible to obtain thorium hydride with a higher concentration of hydrogen than the others; thorium itself is capable of superconductivity; and the hydride is not paramagnetic. Since paramagnetism is the slight reinforcement of the magnetic fields inside a material, paramagnetic substances cannot be superconductors.

Using a commercial grade of thorium hydride that turned out to be really about 80 percent thorium oxide, Professor Satterthwaite's research group found evidence of its anticipated superconductivity by placing a sample of the hydride in the core of a transformer specially constructed to monitor diamagnetism. Later experiments with more purified samples confirmed their discovery. At one degree above absolute zero, pure thorium hydride proved to be totally diamagnetic. Although it decreased gradually, the diamagnetism was sustained up to a transition temperature between 8 and 8.5 degrees Kelvin. The transition temperature is the point at which a substance ceases to be superconducting, and most substances change abruptly. Professor Satterthwaite believes the decrease in diamagnetism is the effect of the temperature dependence of the depth of penetration of the external magnetic field and the small size of the particles in the test sample.

Professor Satterthwaite also noted some other interesting properties of the substance. Substituting deuterium for hydrogen in the hydride should have produced a decrease in the transition temperature — the so-called isotope effect. No such effect is evident although the presence of the hydrogen obviously affects the superconductivity since the transition temperature of pure thorium is only 1.4 degrees. In addition, the ratio of hydrogen atoms to thorium atoms is between 3.6 and 3.7 in the superconductor. Another stable compound, thorium dihydride, exhibits no superconductivity.

Although this is the first evidence of superconductivity in this class of compounds, Professor Satterthwaite believes that other substances will be found with the possibility of transition temperatures as high as any known superconductor. The higher the operating temperature of the superconductor, the easier it is to build scientific equipment such as particle accelerators that can make use of superconducting properties. ●

GETTING THE LEAD OUT

"The annual rate of lead combustion, some 490,000,000 pounds, and the fact that the amount is increasing at an average annual rate of 5 percent per year, suggests that the threshold limit at which widespread biotoxicity may occur may not be too far ahead."

On that ominous note, Professor Robert L. Metcalf, head of the Department of Zoology at the University of Illinois at Urbana-Champaign, and Benjamin B. Ewing, Professor of Sanitary Engineering and of Nuclear Engineering and Director of the University of Illinois Water Resources Center, requested sponsorship for a broad, interdisciplinary investigation into the causes, effects, and prevention of lead pollution.

The National Science Foundation has provided $211,800 for the first two steps in the investigation — planning the approach and establishing an analytical laboratory for preliminary determination of the lead content of soils, water, plants, and animals. The investigation is expected to draw extensively on the resources of the University, including the expertise of faculty members of many disciplines, the laboratory facilities, and collections of soil, plant, and animal matter dating back more than half a century. As one of the activities of a planned effort in environmental studies, the lead pollution research is "a University-wide effort to explore the total dimensions of this important problem in environmental quality."

The analytical laboratory, which will play an important part in the investigation, is being established by Professor Arnold M. Hartley of the Department of Chemistry and Chemical Engineering. Faculty members from the College of Agriculture, the School of Life Sciences, and the Illinois State Natural History Survey are involved in the initial selection of test samples and in the interpretation of the ecological significance of the results. Eventually, more than five thousand samples of plant and animal tissue, water, soil, and stream and lake bottom mud will be analyzed each year. Part of the activity in the laboratory will be devoted to developing the techniques necessary to perform such analysis.

Twenty-two different projects in fields ranging from microbiology and food science to civil and mechanical engineering already have been proposed to be part of the investigation. Under the supervision of Professors Ronald W. Woodhead and John W. Mehin of the Department of Civil Engineering, the compilation of data and computer simulation of the distribution of environmental lead contamination is being undertaken immediately to determine sites and rates of accumulation. Work on the public health aspects of lead contamination will be conducted by Dr. Bertram W. Carnow of the University of Illinois at the Medical Center, Chicago.

Among the other activities suggested for later inclusion in the program are: study of the physiological effects of lead intake on animal behavior and reproduction; examination of the effects of lead pollution on the health of children in cities; development of methods to eliminate lead from automobile exhaust; and evaluation of the economic significance of changes in petroleum refining, gasoline additives, and possibly in the entire technology of the internal combustion engine. In addition, the legal problems inherent in federal and state regulation of lead pollution will have to be examined. ●

WATCHING THE BIRDIE IN 3-D

It is entirely possible that the appearance of William R. Dolson on the University of Illinois campus has chagrined a number of graduate students working with holography — the technique of taking three-dimensional pictures using laser light. Holography is such a recent development that both its application and the techniques of its employment have not yet been explored fully. Although Dolson, who graduated last June from the Loyola Academy of Chicago, is only beginning his freshman year at the University, he already has been working with holograms for three years. Speaking like an authority on the subject to the faculty members and graduate students he met during his visit last summer, Dolson described his work with gelatin holograms using bleached emulsions. He now is continuing his independent study for undergraduate credit under the direction of Professor Raj Mittra of the Department of Electrical Engineering.

One application of considerable interest — the use of holograms for computer data storage — is being explored by Dolson. Not only can a two-dimensional hologram store a three-dimensional image, but also, several images can be stored on the same plate. Altogether, this represents a device for a computer memory that could store a great deal of readily accessible information. While Dolson is examining some of the possibilities in this realm, graduate student Walter J. Atkins, under the supervision of Assistant Professor Preston L. Ransom, will be studying the creation of holograms by computer.

Because holograms rely on the interference pattern of light waves, both the subject and the illuminating optics must be extremely stable. Movements as slight as one-

William R. Dolson, a high school graduate from the Loyola Academy, adjusts a portion of the display photographed as a hologram with a ten-foot depth of field. He prepared the hologram for an exhibition of holography in art media held at the Museum of Contemporary Art in Chicago. Dolson is continuing his work in holography in addition to his other duties as a new freshman in electrical engineering at the University of Illinois at Urbana-Champaign.

hundred-thousandth of an inch can blur a hologram into uselessness. To achieve the necessary stability, Dolson is using a table constructed by Nabi Bayazit for laser coherence measurements. The table, made of concrete and about twelve feet long, rests on partially inflated inner tubes that dampen vibrations. Even so, according to Dolson, the best time to work is around 4:00 a.m. when people and cars aren't around.

The extreme stability becomes more critical as the depth of the subject of the hologram is increased; consequently, most holograms are made of subjects whose dimensions are in inches. The hologram created by Dolson, which displayed the name of the Museum of Contemporary Art of Chicago on four glass plates extending to a depth of about ten feet, put the optical table to a severe test. This particular hologram was part of the display material for an exhibition by eight artists of holography in art media, and represented a pioneering effort in itself.

Everybody should now be thinking back to what he or she did while in high school. And Dolson even seems to enjoy his work. ●

THE SHAPE OF THINGS

Have you ever wondered how topographic maps are made? The method almost universally employed is photogrammetry using either two photographs taken at different observation points or a single photograph with the effect of two points of view recreated optically. The purpose of the two points of view is to record parallax, the optical condition that allows a person to use his eyes or the rangefinder on a camera or gunsight to judge distance.

Although applications related to surveying still represent the prime employment of photogrammetry, the number of nontopographic, close-range applications is growing steadily. To bring together users of close-range photogrammetry in order to exchange ideas, report on new developments in techniques or instrumentation, and inform potential users about its possibilities, the Photogrammetric and Geodetic Engineering Group of the Department of Civil Engineering will host a four-day International Symposium on Close-Range Photogrammetry beginning January 26, 1971.

The broad range of applications of close-range photogrammetry is reflected in a description of some of the topics planned for the symposium. Professor Bertil Hallert of the Royal Institute of Technology in Sweden will report on the use of photogrammetry by police to determine the speed of moving vehicles relative to the speed of their own. Maurice Carbonnell of France will discuss the use of photogrammetry in architecture to accurately record the shape of buildings and their ornamentation so that, in the event of their destruction, they may be faithfully reconstructed. Other topics that will be touched upon are measurement of the rate of growth of farm animals given different feeds, determination of mouth deformation for cleft-palate research, and acquisition of dimensions from design prototypes of automobiles.

Further information about the symposium may be obtained from the chairman, Professor H. M. Karara, Department of Civil Engineering, University of Illinois, Urbana, Illinois 61801. ●

YES, SOME PEOPLE STILL DRINK IT

The Environmental Protection Agency of the State of Illinois and the Department of Civil Engineering of the University of Illinois at Urbana-Champaign are joint sponsors of the Thirteenth Water Quality Conference to be held in Urbana on February 15 and 16, 1971.

This conference, thirteenth in what was formerly known as the Sanitary Engineering Conference series, is entitled "Virus and Water Quality: Source and Control." It is intended to be of interest to scientists and engineers concerned with the problem of water quality as well as managers and operators of water supply and wastewater facilities.

Further information about the conference may be obtained from Vernon L. Snoeyink, Assistant Professor of Sanitary Engineering, 3230 Civil Engineering Building, University of Illinois, Urbana, Illinois 61801, or from

C. W. Klassen, Director, Environmental Protection Agency, Springfield, Illinois 62706. ●

PEOPLE AND PLACES

William C. Ackerman, Chief of the Illinois State Water Survey since 1956 and Professor of Civil Engineering at the University of Illinois at Urbana-Champaign, has been awarded the honorary degree of Doctor of Science by Northwestern University. His expertise in dealing with the problems of water resources was cited in these words: "Officially he serves the State of Illinois, but the calls for his service and the recognition of his excellence are national and international."

Assistant Chief of the Illinois State Water Survey and Professor of Sanitary Engineering, **Thurston E. Larson**, has been elected president of the American Water Works Association. He is the author of more than seventy-five publications and is widely known for his research in water treatment and particularly in problems of water corrosion. The AWWA is an international organization with more than 21,000 members from all parts of the world.

Roger R. Yoerger, Professor of Agricultural Engineering, was named the recipient of one of eight awards for outstanding papers among the 316 published by the American Society of Agricultural Engineers during the past year. The award for the paper, "Simulation of Tractors for Transient Response," written by Professor Yoerger and **Roscoe L. Pershing**, was announced in July at the sixty-third annual meeting of the ASAE.

The nation's outstanding student in foundry engineering, **Larry W. Koch**, graduated from the University of Illinois at Urbana-Champaign last June. He has received the $500 Chester V. Nass Award, given annually by the Foundry Education Foundation and the Beardsley and Piper Company of Chicago. Larry Koch has held a Foundry Education Scholarship for three years. Each of the twenty-seven schools at which the scholarships are awarded may submit a nominee for the national award.

W. Dale Compton, Director of the Coordinated Science Laboratory, has resigned his position at the University to become the director of physics and chemistry research for the Ford Motor Company. Professor Compton served as head of the Coordinated Science Laboratory for five years. His successor, **Clarence Coates**, who received his doctorate here and is returning from the University of Texas, will be joining the Department of Electrical Engineering and assuming his duties as director in September 1971. Professor **Robert T. Chien** of the Department of Electrical Engineering will serve as acting head of the laboratory until Professor Coates arrives.

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COLLEGE OF ENGINEERING
VOL. 12, NO. 3, NOVEMBER 1970

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In the order listed, this issue contains articles on the following subjects:

A CONSTRUCTION MANAGEMENT GAME
HIGH-STRENGTH GLASS STUDIES
WASHINGTON TUNNEL RESEARCH
THE SUMMARY OF ENGINEERING RESEARCH 1970

WHAT'S IN A GAME? OR HOW TO LOSE YOUR SHIRT TO A COMPUTER

In the construction game, winning means profit and profit means growth. But Lady Luck has very little to say about which construction firms will be winners. The project manager who knows how to make the right decisions at the right time is much more important in keeping his employer in the winner's circle.

Before the start of any construction project, whether it be a thirty-story building or a five-by-five tool shed, an estimate of money and time needed to complete the job is made. Once the work is under way, however, the original plan must be changed to allow for various factors which could not be foreseen when estimates were made. For example, a rise in the cost of lumber would affect the total job cost.

How does the project manager learn to make the right decisions at the right time? On-the-job training would be ideal, but the high cost of error makes it impractical. To solve the learning problem, University of Illinois Civil Engineering Professor R. W. Woodhead and graduate student D. W. Halpin have developed a construction management game, played with a computer, which confronts the player with problems that would be encountered in an actual project. The game, Constructo, allows the fledgling manager to make decisions and immediately see the results of his actions.

The object of the game is to complete a project in a specified time and at a minimum cost. A player begins by selecting a project and breaking it down into specific tasks. He then selects labor crews from a pool of available crafts and estimates material and labor costs required to complete the project. For example, preparation of the site may require a foreman and two laborers at a total cost of sixteen dollars per hour. Laying forms for concrete may take two carpenters and a laborer. This information is fed into the computer, which then generates a preliminary estimate — similar to ones which would be available to a real project manager — of construction progress and expected costs. Finally, the computer divides the job into periods, each corresponding roughly to three weeks, and the game begins in earnest.

At the end of each period, the computer gives the novice manager a summary of work completed to date. The total amount of work done, as in real life, depends upon factors such as weather and worker efficiency. Work may not be progressing as rapidly as expected, or the computer may assign five days of unexpected rain during the last interval. These and other similar factors are considered as the computer presents a revised estimate of productivity and cost expected in the next period.

Taking into account the facts presented by the computer, the player must decide how to proceed with the project. He may elect to change the crew makeup (add an extra carpenter), stop an activity (hold off finishing the floor until the roof is complete), work extra days (Sundays and holidays), or proceed as planned.

Presently the game, which will be ready for use in the near future, considers four variables which will affect the outcome of a given job: temperature, days of rain, economic index, and productivity of eleven possible crafts. These variables are translated by the computer into percent of the job complete, cost of the job in labor units and dollars, and days needed to complete the job. The machine also makes predictions of project progress expected during the next period.

Throughout the course of the game, the computer remains completely objective and allows the player to plunge into the game. The computer's only job is to present an existing situation to the player, leaving the entire decision-making process up to him. When the player makes the wrong decision, the machine immediately gives him the bad news, but never the smallest hint of why the decision was wrong or how the situation may be corrected. When the player is correct, he has the satisfaction of seeing his project completed on time and at a profit.

Originally developed as a teaching aid for construction engineering students, the game could be adapted to a wide range of uses. According to Professor Woodhead, the game can be peeled down, like an onion, to various simpler versions suitable for players ranging from undergraduate students to professors. Also, with ever-increasing demands made on the construction industry, Constructo could some day be used as a management training device, thus aiding the industry to win at its own game. Since the game can be played with either teletype console or punched card input, it could easily be used by individuals who are involved with construction but are not trained computer operators. Finally, the game can be used as an information-gathering device when played by experienced construction project managers. Computer responses given by these players can lead to an analysis of decisions which were previously attributed to intuition. Information on how these decisions were reached, which has always been very difficult to transfer from one individual to another, could eventually be used in refining the game itself.

In a sense, Constructo takes the construction engineering student out into the field. It confronts him with a real project and all of the headaches, large and small, that go into seeing the project through to its completion. The student must deal effectively with the unpredictable real world or suffer the consequences of his mistakes. The game is so close to reality that although it can be replayed, random factors keep it from repeating identical situations.

What's in a game? A game is playing, winning, and losing, but, in Constructo's case, it also is learning. It offers the inexperienced project manager an opportunity to get mud on his boots without leaving the classroom. ●

IT'S A BIRD! IT'S A PLANE! IT'S . . .

People in glass houses shouldn't throw stones, especially if they are in a twenty-thousand-mile orbit. Future space stations, as well as more down-to-earth airplanes, may be constructed of fiber glass, instead of metal alloys. Concern for the strength and stiffness of glass has led Professor S. D. Brown of the Department of Ceramic Engineering to investigate basic elastic properties of high-silica-content glass.

The present weakness of fiber glass (plastic with glass fibers) is that existing compositions are still less rigid than their steel counterparts. If the elastic stiffness of the individual glass fibers could be increased, the advantage would be significant.

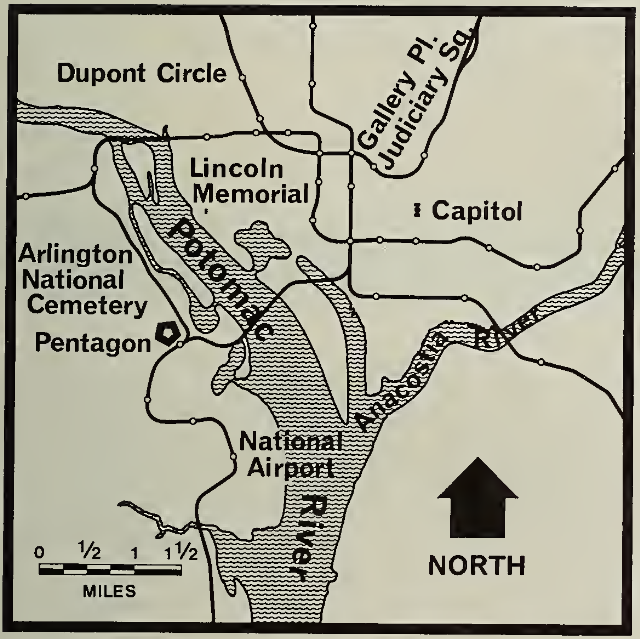
Before the glass fibers can be stiffened, there must be more information on the basic properties of glass. Professor Brown's research is of this fundamental nature. High-silica glass cannot withstand high strain because water attacks the surface and weakens the glass. Under the extremely cold temperatures of liquid nitrogen, however, this glass can be put under a much greater strain than normally possible (up to 12 percent more). Under the increased strain, the high-silica-content glass exhibits a modulus of elasticity (that is, stiffness) twice that obtained at ordinary strains. The understanding of this property of the glass would permit more precise attempts to predict and thereby increase the strength and rigidity of glass fibers.

This promise of fiber glass having high stiffness, as well as a strength-to-weight ratio three times that of steel, indicates a future trend toward fiber glass in aerodynamic construction. There already exist prototype fiber glass planes, and applications have reached as far as the space program. Fiber glass can not only be stronger than steel, but also, since its use in the space program, may be faster than a speeding bullet as well. ●

U OF I CAPITALIZES ON TUNNEL RESEARCH

Digging holes in the ground is child's play, right? Wrong. If the hole is an excavation eighty feet deep, as wide as the street above, and an entire city block long, there are some very complex engineering problems involved. For one thing, unless support is carefully provided, the earth never stays where you left it. The earth around the excavation tends to move in toward the cavity causing changes in the load and stress on its walls and leaving a depression in the ground a short distance away. As more dirt is removed, tons of rock and dirt tend to shift and slide in to replace what has been taken out. Cracking walls and cave-ins make the tunnel itself a safety hazard during construction. Buildings surrounding the site of the digging are subject to cracking foundations and walls. An age-old method of counteracting the effects of adverse geology is to brace the walls of the excavation and underpin the buildings adjacent. Nothing is as simple as it sounds.

The five-billion-dollar Washington, D.C., rail rapid transit system (better known as Metro) is up against a phenomenal set of problems as it begins construction of its more than twenty-five miles of urban tunnels and underground stations. In order to be constantly aware of the variable geologic conditions encountered during excavation, the Washington Metropolitan Area Transit Authority has contracted with the University of Illinois Department of Civil Engineering for installation of in-



This scale-model map shows the downtown route of the Washington, D.C., Metro rapid transit system now under construction and three sites where the University of Illinois at Urbana-Champaign is installing instrumentation to study varying geologic conditions and their effect on tunnel construction.

struments to monitor the earth's movement around tunnel and underground station sites.

The University of Illinois project, under the direction of Civil Engineering Professors E. J. Cording and A. I. Hendron, will include instrumentation at three main sites as well as at numerous smaller excavations in the D.C. area. The three large sites where extensive instrumentation is being installed are Judiciary Square, Gallery Place, and Dupont Circle. All three of these locations are sites of large underground stations.

The excavation at the Gallery Place site must be large enough to leave room for three levels: two tunnels that cross each other and an underground station. In order to measure all stress and strain, some of the instruments used to study the movement of the earth and rock at this particular site were installed even before the actual digging began. One type of instrument being used is a device called an inclinometer which consists of a flexible plastic tubing implanted vertically into the ground. An instrument which can detect whether or not the pipe has shifted or curved from its original position is then inserted into the pipe. Readings are taken periodically throughout the tunneling and sent back electronically to University of Illinois computers.

Most of the national monuments and important buildings around the route of Metro are being painstakingly underpinned as a precaution against cracking. The next step is to find appropriate ways of bracing the tunnel ceilings and walls against the pressures exerted by shifting earth and cracking rock formations.

In the past, engineers have braced the walls of their excavations with a metal framework which they have then embedded in a thick concrete supporting wall. This method is not very economical and also does not adapt well to all geologic conditions.

In order to design a particular type of support system for a particular set of geologic conditions, an elaborate analysis would have to be made for each excavation site. This is just too expensive. The alternative plan is to adopt a semiempirical plan — a sort of "learn as you go" concept. This is where the University's instrumentation and observation come in. A preliminary design can be modified en route to the finished structure as information is gathered from the instruments around the site. Factors such as shape, size, and differing types of support elements can be varied within certain limits during actual construction.

The basic design for most rock tunnels will be an arch supported by steel bolts running from the wall of the tunnel back into the rock. The arch is then sprayed with a thin layer of concrete called shotcrete which is both a protective covering and a support structure. The entire shell is monitored for stress from the beginning of construction to the end.

Although an instrumentation program of this sort is planned primarily to help increase construction safety, the information obtained will be invaluable in planning future tunnels, safely and economically, and increasing the general knowledge about tunneling. ●

FALL TURNS OUT *SUMMARY*

The Summary of Engineering Research 1970, which describes the $15 million research program of the College of Engineering at the University of Illinois at Urbana-Champaign, will be available in the latter part of November. The *Summary* describes briefly the more than 600 research projects conducted in the College of Engineering, including the Department of Physics and the Department of Computer Science of the Graduate College.

The *Summary* includes not only capsulized project descriptions, names of sponsors, investigators, and federal contract numbers, but also an extensive listing of related literature.

Copies of the *Summary* will be available free to students and faculty members of the University of Illinois and for a dollar handling fee to persons outside of the University. Copies may be obtained from the Engineering Publications Office, University of Illinois, 112 Engineering Hall, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

The Eighth Stanton Walker Lecture was delivered on November 18 at the University of Maryland by Professor **Clyde E. Kesler** who holds professorships in both the Department of Theoretical and Applied Mechanics and the Department of Civil Engineering at the University of Illinois at Urbana-Champaign. Past president of the American Concrete Institute and internationally known for his research, Professor Kesler discussed "Fatigue and Fracture of Concrete."

The doctoral thesis of graduate student **Malay Chaudhuri** has received second place in the Academic Achievement Competition of the American Water Works Association. The research for the thesis was conducted through the University of Illinois Water Resources Center and was sponsored by the Office of Water Resources of the U.S. Department of the Interior. Entitled "Virus Removal by Chemical Coagulation," the dissertation examined and explained the chemical treatment of water to flocculate and coagulate (gather into lumps) the viruses it may contain. The research also indicated that viruses concentrated in discarded sludge are still alive and warned that the sludge should not be disposed of in areas where it can be washed directly into public water supplies.

Professor **Herbert E. Carter**, Vice-Chancellor for Academic Affairs at the Urbana-Champaign campus, has been elected chairman of the National Science Board, policy-making body of the National Science Foundation. Professor Carter, for thirteen years head of the Department of Chemistry and Chemical Engineering, was first appointed to the board in 1964 by President Lyndon B. Johnson and was reappointed in May of this year by President Richard M. Nixon. He was elected unanimously at the board's twentieth annual meeting.

President Nixon has also named Professor **Jerry S. Dobrovolny**, head of the Department of General Engineering, to a three-year term on the National Advisory Council on Vocational Education. The twenty-one-member council meets at least four times a year to advise the federal government and to evaluate existing programs in the field of vocational education. In June, Professor Dobrovolny received the Arthur L. Williston Award of the American Society for Engineering Education for "highly significant publications in technical institute education."

A new name reflecting a new activity has been given to a University of Illinois building. The structure, built in 1943 as the Sanitary Engineering Laboratory, has been renamed the **Environmental Research Laboratory.** Sanitary engineering activities moved from it some time ago into the new Civil Engineering Building. The laboratory is now used for analytical work on a new interdisciplinary research program in environmental lead pollution and other environmental research in a growing program of new activities. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 12, NO. 4, DECEMBER 1970

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AT URBANA-CHAMPAIGN

In the order listed, this issue contains articles on the following subjects:

HUMANITIES-ORIENTED PHYSICS COURSE
FLIGHT CONTROL SYSTEMS RESEARCH
ENGINEERS DISCUSS THE ENVIRONMENT
ENVIRONMENTAL STUDIES INSTITUTE

PHYSICS FOR PEOPLE

Laura, an undergraduate student in humanities, doesn't like physics. Her reasons are quite simple and very understandable. She doesn't know and understand mathematics, which has always been the language of physics. Furthermore, she equates science with technology, and her generation often finds a lack of concern for humanity in technology. To Laura, there exists no relationship between her chosen field and physics. She is intelligent and knowledgeable in her field, but society has allowed her to alienate herself from science and has told her that this alienation is acceptable. Philosopher C. P. Snow calls this situation, in its most sophisticated state, the two-culture gap. Whatever it is labeled, the problem exists, and a number of educators are seeking solutions.

David Lazarus, Professor of Physics at the University of Illinois at Urbana-Champaign, believes he has found a possible solution to the problem. Beginning in February 1971, he will teach a course for nonscientists entitled, "Physics and the Modern World." Basically, the course will cover those philosophical concepts in physics which can be found in the arts and sciences: model-making, dynamics, ensemble behavior, and symmetry. This course will be open to students in all fields.

The course will not be a survey, and no attempt will be made to follow the usual mathematical and historical lines of an introductory physics course. Illustrations will be drawn chiefly from topics in modern physics and their applications and limitations which are relevant to our technological environment. Mathematics will be at a minimum, and the level of presentation will be that appropriate to the humanities student. The student will be given the opportunity to discuss, question, explore, and hopefully understand the relationships between modern physical thinking and his view of the world.

Professor Lazarus has been mulling over in his mind for a number of years the idea for the course. Among his family and friends there are a sufficient number of "Lauras" to involve him personally with the problem of scientists communicating with laymen. Essentially, he feels that the physicist must interact with society. He maintains that the scientist must learn to verbalize rather than present his findings in mathematical terms. On the other hand, he disagrees with the notion that the scientist is constantly cold and always rational. According to him, the physicist reacts in much the same way that the artist does when he reaches a moment of insight.

Modern Physics and Antiphysics by Adolph Baker will be required reading for the course. Professor Lazarus was a consultant for this book, which was written primarily for nonscientists. An open, supervised laboratory will be available to students who wish to try original experiments. The laboratory work, however, will be optional. Grading will be on the verbal level, with possibly two term papers required. Students will be encouraged to find their own term paper topics, which will hopefully involve an interplay between science and society.

In general, the course will be structured to stimulate people of various disciplines to think in terms of physics. It will offer them an opportunity to understand the underlying currents in modern physics and also to see the limits of its analytical tools as they are often applied in other areas. Hopefully, it could be the beginning of an interdisciplinary exchange program that will affect thinking inside and outside of the University. Most important, the course should offer a foundation for bridging the two-culture gap. ●

DIAL "E" FOR ENGINEERING

The University of Illinois at Urbana-Champaign and the University of Wisconsin are cooperating in a plan for extension education in engineering. Dean Stanley C. Robinson of the University of Illinois Division of University Extension is directing the establishment of an educational telephonic network program between the Madison campus of the University of Wisconsin and the Urbana-Champaign campus of the University of Illinois to make increased course offerings available to professional practicing engineers in both states.

Through the system, students at either institution will be permitted to enroll for credit at their own campus in courses offered via the telephone network at the other university. Degree credit will be under the jurisdiction of the respective colleges of engineering. ●

OR WAS IT WILBUR?

One day, Orville decided to sit up for a change, since his white smocks were getting too dirty from his lying on his stomach. Since that momentous day in man-machine engineering, the basic relationship between pilot and plane has not changed very much. Meanwhile, the machine and control systems have become extraordinarily complicated and sophisticated.

Today's busy commercial pilot has a lot on his mind, and hands, besides merely flying the plane. Communications, navigational controls, passenger comfort, and the circuit breaker for the in-flight movie projector all demand the pilot's attention.

As a pilot, Emmett Kraus is concerned with increasing efficiency between a pilot and his controls. As an instructor in the Department of Aeronautical and Astronautical Engineering at the University of Illinois at Urbana-Champaign, Kraus is working to create a more functional unit composed of the pilot and his machine.

Existing flight control systems fall between two paradigms: flying to a destination and control operation. One extreme is a completely automatic pilot which is programmed for any contingency. Thus, if a flight were scheduled from Chicago to New York, the pilot could merely press the O'Hare to JFK button, and leave the flying to the automatic pilot-computer. This device would be immensely complicated for its program to include all deviations possible, including wind speed, reroutings, circling patterns, ad infinitum. On the other end of the spectrum is a manual system requiring the continuous coordinated manipulation of the ailerons, elevator, rudder, and throttle. The pilot directly controls everything in a maneuver. Existing control systems fall somewhat closer to this last system.

To change his position to get on a radio beam, a pilot wants to make, let us say, a thirty-degree change of course. He turns the wheel which lifts and lowers the ailerons on the wings. The ailerons create drag problems which initially tend to turn the aircraft the wrong way, while the tilt of the plane creates a change in the lifting effect such that the airplane goes slightly downward, as well as turning. To compensate for the initial yaw in the wrong direction, the pilot must compensate by changing the rudder with his foot pedal. To overcome the downward motion, the pilot must change the elevator, pull on the wheel or stick, and change the power to the engines to compensate for the change in speed due to the maneuvering.

This "simple" change in direction consumes the pilot's time and energy, especially when such maneuvers must be repeated in long flights. Kraus is working on a happy marriage between automatic and direct control at the University of Illinois Aviation Research Laboratory. His system will permit the pilot to simply turn the wheel to accomplish a turn maneuver. The control system will do all the compensation and coordinated manipulating automatically. Thus, the change of position will become much more simple for the pilot, demand less of his attention, and fatigue him less.

The long-range outcome of the project will provide more direct control of the status of the aircraft, as given in terms of position in space, attitude, and performance. This will relieve the pilot of the time-consuming and fatiguing effort required to ride herd on direct mechanical links to everything on the plane that moves, and so remove him from the inner workings of the control system, giving him management control over the overall aircraft status. Not only will this lessen the possibility of accidents due to pilot fatigue, but will free the pilot to concentrate on important things in his flight — like the circuit breaker for the in-flight movie projector. ●

PROGRAM OFFERS ELECTRONIC INSIGHT

The twelfth annual summer program in Electronics for Scientists at the University of Illinois at Urbana-Champaign has been announced with receipt of a $38,380 grant from the National Science Foundation.

Under the direction of Howard V. Malmstadt, Professor of Chemistry at the University, the course will be presented June 26–July 17, 1971. Professor Malmstadt developed the program to take the mystery out of electronic devices essential in today's scientific world. Chemists, physicists, medical scientists, engineers, teachers, and research workers — people who use electronic devices but have little or no background in how they operate — will be accepted for the course. ●

Fatigue crack growth rates are being investigated by the Department of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign. The section here being closely studied by graduate student A. Grandt is subjected to pure bending and shows the photoelastic fringe patterns at the crack tip.

RECYCLING ENGINEERS

If the present trend continues, an E.E. degree may no longer automatically designate an electrical engineer, but may also denote an environmental engineer working on ways of cleaning up the earth. This was the consensus of a group considering "The Environmental Crisis," one of six discussion topics of the Big Ten Undergraduate Engineering Council's Conference held at the University of Illinois at Urbana-Champaign this November.

"Crisis" not only describes the present state of the environment, but also the state of the solution. Money is no longer the single missionary force that can correct any problem. Presently, over one billion dollars in federal funds are unused because of the lack of trained personnel to formulate, process, and implement sorely needed projects — a critical shortage of sanitary engineers, environmental consultants, and construction companies specializing in waste-removal systems. Overcontracted companies rely heavily on overtime, which boosts costs; a pump or major component takes from eight months to one year for delivery. With the status quo, these inadequacies cannot be met for five to ten years.

Presently, the sanitary engineering student is in the envied position of averaging twelve job offers upon graduation. He is recruited by federal, state, and municipal agencies, as well as industry. He may find himself at the management level, influencing the initial decision-making process affecting a major pollution problem. Thus, he faces a rather different situation than the technical, goal-oriented problem solving most engineers are used to. This new professional status carries with it a responsibility that an overspecialized engineer is not always equipped to handle.

One professor informed the discussion group that while legislators determine the direction and magnitude of government programs directly affecting the engineer's professional career, only nine congressmen have any technical background. Engineers must contribute their technical knowledge to the decision-making process that assigns priorities to an SST system or a sewage treatment system, just as they do in private industry.

While the University of Illinois at Urbana-Champaign is currently considering an Environmental Research Laboratory, isolated, academic involvement is not enough. Engineers, both students and professionals, must become personally involved in local environmental crises, using their unique skills and personal interests and biases to combat the problem. One electrical engineering society has modified its initiation into a practical project attacking a local environmental problem. Too often, local conditions are not rectified because the inhabitants are used to it, or living off it.

The group agreed that an integrated, interdisciplinary approach is needed for environmental problems. Not only is a technically sound solution needed, but also one that is socially, economically, and ethically responsive. This broadened orientation must come from the engineer's education as well as his personal activity. ●

ENVIRONMENTAL TEAMWORK

In an effort aimed at "putting it all together," the University of Illinois at Urbana-Champaign is proposing an Environmental Studies Institute which will develop a new generation of problem-oriented scientists and engineers and help to restore the quality of the human environment. With emphasis on team research, the institute will be concerned with the correction of undesirable conditions and with the long-term evaluation of the physical, biological, and social environments of man.

In a recent report recommending the institute, a faculty committee, under the chairmanship of Civil Engineering Professor Ben B. Ewing, pointed out that the colleges and departments of the University already have extensive programs of research which are closely related to the environmental sciences. However, increased activity in the environmental area will require reorientation of present work and new interdisciplinary programs and facilities. As an example, the committee noted the University's recently inaugurated interdisciplinary research project on lead pollution (See *Outlook,* September 1970), whose activities would become part of the institute. Other existing interdisciplinary research units which might be transferred to the proposed institute include the Center for Human Ecology and the Water Resources Center.

The institute could draw extensively from a pool of existing projects, specialists, and facilities to expand and transfer environmental knowledge with an emphasis on the problem-solving use of the knowledge. With the institute to marshal the University's academic resources, an interdisciplinary team will mount a massive attack on the problems of maintaining the quality of man's environment. ●

PEOPLE AND PLACES

The Office of University-Industry Relations recently announced that the Andrew Corporation of Orland Park, Illinois, and the Zenith Radio Corporation of Chicago are sponsoring three new industrial research assistantships in the College of Engineering at Urbana-Champaign. These companies, among the first to establish industrial research assistantships when the college first announced the program five years ago, provide $7,500 to cover salary, material, equipment, and other costs for three semesters of research into an area of interest. The new research assistantships were awarded to graduate students in the college's Department of Electrical Engineering and are supporting research into antennas and fast-pulsed holography.

Study and research grants totaling $22,500 have been awarded the University of Illinois by the General Electric Foundation. The grants include $10,000 to Professor **C. T. Sah,** Department of Electrical Engineering; $7,500 to Professor **James W. Westwater,** head of the Department of Chemical Engineering; and $5,000 to Professor **John E. Baerwald,** Department of Civil Engineering and director of the Highway Traffic Safety Center.

Professor **Nick Holonyak, Jr.** of the Department of Electrical Engineering has been named to the National Research Council committee on electronic materials and devices. His specialty is semiconductor devices, and in 1962 he received the Cordiner Award for the first visible-spectrum semiconductor laser. He is a fellow of the Institute of Electrical and Electronics Engineers and a member of the institute's editorial board. The National Research Council, the operating arm of the National Academy of Sciences and the National Academy of Engineering, is dedicated to the advancement of science and technology and their use for the general welfare.

The current issue of *Electronics Digest* magazine has honored Professor **John Bardeen** of the Departments of Physics and Electrical Engineering, University of Illinois at Urbana-Champaign, in its "History's Hall of Honor — biographical sketches of great men in electronics" series. History will remember Professor Bardeen's work on the invention of the transistor for which he was a corecipient of the Nobel Prize in Physics in 1956, and his more recent research into superconductivity carried on at the University of Illinois. ●

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COLLEGE OF ENGINEERING
VOL. 12, NO. 5, JANUARY 1971

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AT URBANA-CHAMPAIGN

inside outlook:

MOTORCYCLE SAFETY RESEARCH
COMPUTERIZED CHEMISTRY COURSE
DEAN SPEAKS TO AAAS
WATER QUALITY CONFERENCE SLATED

NOT SO EASY RIDER

The number of motorcycles on Illinois streets and highways has increased greatly during the past few years. This multiplication of machinery has brought delight to a new generation of motorcyclists, dismay to many non-cyclists, and financial security to a few Japanese manufacturers. But to those charged with the responsibility for traffic safety, their appearance has caused near panic.

The need for improved safety measures lead the Illinois secretary of state to establish the Motorcycle Driver's Licensing Evaluation Committee. The committee, under the direction of the Highway Traffic Safety Center at the University of Illinois at Urbana-Champaign, was to recommend suitable tests, procedures, and policies for maintaining an efficient program of cycle licensing. Chief investigator for the project was LeGrand L. Malany, instructor in the U of I Department of General Engineering.

The committee's task was not an easy one; motorcycling is far more complicated than just balancing on two wheels. Surprisingly, the probability of cycle accidents is not much greater than that of automobile accidents, but injuries incurred in a cycle accident are more severe. Most cyclists are in the high accident rate group, between the ages of eighteen and twenty-three. Training facilities for motorcyclists are virtually nonexistent, and training procedures are not uniform. Even the cycles themselves are not uniform, ranging from twenty-inch-high "mini-bikes" to eight-hundred-pound "road hogs." To cap these difficulties, there is the problem of getting the public to accept motorcycles and to integrate them into the traffic flow.

When the committee began its research, there was very little material available on motorcycle licensing and safety. All types of cycles, from the smallest to the largest, were classified together under the Illinois motor vehicle law, and there was no motorcycle driver's testing program. Consequently, the group's first activity was to classify the various types of cycles and to discuss and hone in on the skills needed to drive them. This was relatively easy since most of the committee members drove motorcycles. Once the skills were identified, the group attempted to find out how they were testable.

With their own information, and the help of licensing data from other states, the committee drew up a rough draft of a skill test for the most common type of two-wheeler. Then, relying on their own skills, the committee got on cycles and tested their test. After that, it was back to the drawing board for further refinements. How can hand and foot integration be tested? How can a sense of balance be measured objectively? The resulting effort was too involved for presentation to the public, so volunteers were given the test and two dollars for their efforts in helping to improve motorcycle safety in Illinois.

Seventy-two persons participated in the trial skill test. All major motorcycle sizes, ranging from 50 cc to 1209 cc engines, were represented. Driver ages fell between sixteen and fifty-two years, with good representation at all age levels. Most participants successfully completed all phases of the test. For example, no one showed difficulty in performing the "slow ride," which checked balance and measured ability to control the cycle at very low speeds. The "serpentine ride" measured the driver's ability to shift his weight from side to side while operating the cycle through continual changes in direction. Most of the cyclists using the extremely large cycles were able to execute the tests with the same proficiency as the drivers of smaller cycles, a totally unexpected result. Data from the trial skill test were used to develop criteria and scoring standards used for the final test recommendation.

The skill test, along with separate tests for mini-bikes and three-wheelers, was published in a final report which also contained the committee's findings in other areas of cycle safety. These areas include objectives and design of a licensing program, written and physical examinations, and the materials necessary to establish skill and road tests. The Illinois secretary of state's office has begun to implement the report and has used the committee's findings to develop a special examiner's manual for use in the field as an aid to administering motorcycle skill and road tests.

To date, there has been no follow-up evaluation study, which Malany feels is essential to the maintenance of a sound motorcycle licensing program in Illinois. Also, much needs to be done in the areas of training both riders and licensing examiners. However, establishment of the committee and its subsequent findings have started the wheels rolling for safer cycling in the state. ●

The predominantly male world of engineering is graced by some forty-nine young women enrolled in the College of Engineering of the University of Illinois at Urbana-Champaign. Here, research assistant Sai Lee and graduate student Elaine Greening are testing the resistance of bacteria to chlorinated water in environmental research for the Department of Civil Engineering.

PUTTING PLATO TO WORK

In this age of instant breakfasts and instant replays, an organic chemistry laboratory experiment still lumbers along like a dinosaur in a world of supersonic transports — that is, unless the experiment can be carried out with a computer. Getting results in less than a second to experiments which elsewhere take days or weeks is one special feature of an introductory organic chemistry course developed at the University of Illinois at Urbana-Champaign by Chemistry Professor Stanley G. Smith. The course involves the PLATO (Programmed Logic for Automatic Teaching Operations) computer-based education system (*Outlook,* January 1969) which originated with Professor Donald Bitzer, director of the U of I Computer-based Education Research Laboratory.

The development of PLATO offered Professor Smith an opportunity to provide each student, even in a large class, with individual attention. There are a number of ways of presenting lecture material, but whatever method is used, many students still memorize rather than analyze ideas. A lecture often tends to reach only a few members of a large class, confusing some students and boring others to sleep. During a lecture or demonstration, it is very difficult for an instructor to be aware of and respond equally to the needs of each class member. This situation is not so with PLATO. The student is directly involved, and his decisions trigger computer responses which indicate his progress.

Presently, the PLATO system consists of twenty student stations, each equipped with a television screen and a keyset. Information displayed on the screen includes words, numbers, formulas, graphs or diagrams drawn by the computer, and images selected by the computer from a set of slides. The student uses the keyset to ask and respond to questions and supply parameters for experiments. If the student has difficulty, extra help can be obtained automatically. The computer also provides a printed record of every student's work, making it possible for the instructor to review the progress of each individual.

A significant component of an introductory course in organic chemistry is the chemistry of aldehydes and ketones. The PLATO lesson in this area combines tutorial techniques, drill, and simulated experiments. In textbooks and lectures, the results of experiments are presented as facts to be learned, and the student is not given an opportunity to study phenomena through exploration. Also, chemistry texts usually give only one answer to a problem, while there may be many. PLATO can be programmed so that the student may investigate a number of possible solutions.

In effect, the student is able to ask the computer to perform a series of experiments and report the results. When an experiment is completed, the student is immediately asked questions which can be answered if the correct procedures have been followed. If the student cannot answer the questions, the program indicates the type of experiment he should investigate and directs him back to that part of the lesson. Through this procedure, the student can learn by discovery rather than by copying from the blackboard.

Identification of unknown compounds is another important aspect of an introductory organic chemistry course.

When using PLATO, the student must identify unknown compounds by formulating questions and interpreting the results of experiments. Information being requested by the student is determined by key words and phrases, with one to four words defining the question. Presently the program recognizes over two hundred key words and formulas, along with many common English words.

Student: Does it smell
PLATO: It has an almond-like odor

Student: Is it a liquid
PLATO: It is a liquid at room temperature

Student: Where does it boil
PLATO: The boiling point is 189°-191° at 760 mm

Student: Show me the infrared spectrum
PLATO: This is the ir spectrum (The infrared spectrum is displayed on the screen.)

Student: Try hot aqueous NaOH
PLATO: Hydrolysis in aqueous base followed by treatment with acid yields a compound with a mp of 120°-121°

The unknown is

Student: Benznitrile
PLATO: Sp

Student: C_6H_5CN
PLATO: OK

Future expansion will greatly increase PLATO's "vocabulary." Should PLATO not recognize a word, the word and an explanatory comment are written at the bottom of the screen. This type of lesson permits a student to test several approaches to the identification of an unknown compound before he goes into the laboratory.

Professor Smith is currently putting the organic chemistry course through a trial run by offering it to volunteer students. In approximately two years, PLATO will have the capacity to handle two thousand students at one time, and Professor Smith plans to have the course in full gear by that time. When the course is offered, it will not only add a new dimension to the teaching of organic chemistry, but it will also broaden PLATO's scope by getting the system out of the computer laboratory and into the classroom. ●

DEAN CALLS FOR "TWO-CULTURE" COOPERATION

A union of scientists, engineers, and social scientists in new interdisciplinary efforts may be the greatest challenge faced by the nation's universities during the next decade. This is the assessment of Daniel C. Drucker, Dean of Engineeering at the University of Illinois at Urbana-Champaign. In a speech delivered to the American Association for the Advancement of Science, he offered his judgment of the future of university involvement in the pressing problems of society.

Drucker said the severe attack engineering is currently experiencing is the result of two phenomena, both of which are related to the affluence of our society. "One occurs in society at large. It is the increase of the scale and intensity of pollution of our environment to the point where it produces near panic in our highly urbanized civilization. The other occurs in a very special society, the university or college society with its increasingly vocal and often alienated segment of our population."

"One of the greatest challenges of the next decade or two within the universities is to attempt to create a discipline lying between engineering and the social sciences. Such a true interdisciplinary effort can be meaningful and successful only when first-rate engineers and first-rate social scientists interact as equals. I view the engineer, operating at a very high level, as the driving force in a partnership of intellectual equals because he is oriented to action as well as study."

Will this happen? Not necessarily, Drucker feels. "Periodically a wave of anti-intellectualism sweeps over the country and sometimes the world. We are in such a period now; the wave is frighteningly strong. The public through its elected officials and representatives may lash out in rage and accomplish what the ill-intentioned activist groups try unsuccessfully to do. Like a blind Samson, they may tear down the structure of higher education, destroying the major good along with the minor evil." Without engineers and scientists in requisite number, Drucker concluded, the clamor to solve problems will be ever more articulate and solutions ever less possible. ●

EARTHY BULLETIN AVAILABLE

Recommendations for Stabilization of Illinois Soils, the first statewide handbook of data on soil types and properties important in soil stabilization for roads, highways, and parking lots, has been compiled in the Engineering Experiment Station of the University of Illinois at Urbana-Champaign.

The 225-page bulletin is a practical user guide for state, county, and city highway departments, consultants, and contractors involved in constructing pavements. It presents technical recommendations fitted to local conditions for practical use of soil stabilization techniques involving cement, lime, lime-fly ash, bitumen, and combinations, and includes tables of soil types based on maps and surveys by the University's College of Agriculture. The authors are Professor Marshall R. Thompson of the U of I Department of Civil Engineering and Quentin L. Robnett, graduate assistant in that department.

Engineering Experiment Station Bulletin 502, *Recommendations for Stabilization of Illinois Soils,* is available for $3.00 from the Engineering Publications Office, University of Illinois, 112 Engineering Hall, Urbana, Illinois 61801. ●

NUMBER THIRTEEN UNLUCKY FOR VIRUSES

"Virus and Water Quality: Occurrence and Control" is the name of the thirteenth in a series of conferences on water quality held at the University of Illinois at Urbana-Champaign. The conference, which is scheduled for February 15–16 will attract sanitary engineers, researchers from the fields of microbiology and virology, and public health and water hygiene officials. This conference is sponsored jointly by the U of I Department of Civil Engineering and the Environmental Protection Agency. Further information may be obtained from Vernon L. Snoeyink, Assistant Professor of Sanitary Engineering, 3230c Civil Engineering Building, University of Illinois, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

Professor **Raj Mittra** of the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign has been honored by the Institute of Electrical and Electronics Engineers by election to its highest honor, the grade of fellow. Mittra, who is on the staff of the U of I Antenna Laboratory, was cited "for contributions to electromagnetic theory as applied to the solution of problems in antennas and waveguides." The grade of fellow is conferred by the institute on persons of outstanding qualifications and eminent achievement in their particular fields of interest.

Frederick Seitz, distinguished physicist who left the University of Illinois at Urbana-Champaign to become president of the National Academy of Sciences and who is now president of Rockefeller University, has just received the highest award of the American Institute of Physics. President Seitz, the fifth person so honored, received the Karl Taylor Compton Gold Medal for "distinguished statesmanship in science." The citation recognized President Seitz for "his outstanding service to physics and to science as a pioneering researcher, noted educator, able administrator, and effective government advisor."

University of Illinois Professor **Roger A. Schmitz** and former graduate student **Ronald B. Root** will share in the one-thousand-dollar Allan P. Colburn Award for the outstanding research paper by younger members of the American Institute of Chemical Engineers. Requirements for the award include the stipulation that authors must be under thirty-five years of age when the paper is submitted for publication. Professor Schmitz is the sixth person from the chemical engineering faculty of the University of Illinois at Urbana-Champaign to receive this award. ●

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engineering outlook

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 12, NO. 6, FEBRUARY 1971

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AT URBANA-CHAMPAIGN

inside outlook:

ENGINEERS ATTACK URBAN PROBLEMS
AN INVESTIGATION OF SOYBEAN LOSS
TEACHING COMPUTERS ENGLISH
ACE SURVEY RESULTS

BUILDING COMMUNITY BRIDGES

Poor people have problems. Some of these problems engineers can help solve. The Department of Civil Engineering of the University of Illinois at Urbana-Champaign, working with Champaign's Community Advocacy Depot, is helping poor people to better their physical, economic, and social environment.

The Depot draws on civil engineers, as well as faculty and students of other departments, for consultation on specific urban problems. Professor Robert A. Eubanks serves as liaison between the University's Department of Civil Engineering and the local black community. Involved are some dozen individuals aiding in problems of housing construction.

An outgrowth of CAD is the Afro-American Consolidated Contractors Organization. This recently formed group of craftsmen and tradesmen lacks experience and background in the intricate managerial skills required of a successful contractor. Students and faculty of the Department of Civil Engineering assist in project estimation and bid preparation, job planning on the building site, and accounting and cost control. Administrative assistance is also provided in funding requests and in obtaining placement on various bidding lists. The contractors have gained seven contracts which employ about 150 persons, most of whom live in the black community.

Young black apprentices of these building trades are learning necessary skills through night classes presented by the engineers. As community self-help grows, the projects become more independent of University guidance, and the technical assistance turns to other projects.

A group of students is conducting a study of housing rehabilitation in the black community, under the supervision of Assistant Professor George Birrell of the Department of Civil Engineering. Their feasibility study includes industrialized housing suited to the community's housing needs, and a factory to produce building components for sale to local builders.

Often, one project fosters the next. The housing study needed to know what features these dwellings should have. Too often, the salient differences of life styles have been overlooked in the usual approach to urban renewal. One life style may view a kitchen as a small, functional room in which to prepare meals, while another may see the huge kitchen table as the social center of the household. An interview program was initiated to determine the most beneficial house plan. A doll-house-modeling approach to interviewing is being improvised to help the poor conceptualize how they would like their homes arranged, using miniature furniture and rooms to communicate their ideas.

Specific-problem courses related to CAD projects are also offered by the University. They are task-oriented and educationally beneficial for both graduate and undergraduate levels. The Department of Civil Engineering also sponsors undergraduate independent research related to the CAD program.

Documentation of the program should yield publishable material, outlining the problems and solutions. More important is the communication of the process that these solutions entail, underscoring the social responsibility of the engineer. The poor are the clients who accept or reject technical answers offered by the engineers. Both parties learn by the shared experience of the mistakes, as well as the successful solutions. The student learns that good engineering demands more than a knowledge of books and blueprints; it demands a knowledge of people as well. ●

TEACHING TEACHERS TECHNOLOGY

The eleventh Summer Institute in Engineering Technology for Junior College and Technical Institute Teachers will be held June 21–August 14, 1971, at the University of Illinois at Urbana-Champaign.

Part of a nationwide National Science Foundation program to meet an acute shortage of well-prepared engineering technology teachers, the institute will be supported by a $57,460 NSF grant. It will be under the direction of Professor Jerry S. Dobrovolny, head of the University's Department of General Engineering. The summer work will offer thirty teachers an opportunity to receive intensive training in machine design technology or in electronic technology.

Illinois is the only university which has offered the summer institutes every year since 1961. NSF grants for the eleven years have totaled $573,680. ●

$TOPPING $OYBEAN $HATTER

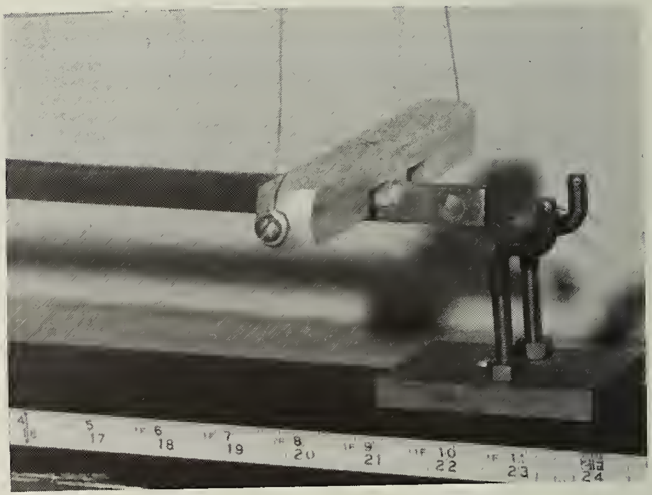
Why would a Ph.D. specializing in theoretical and applied mechanics spend five years breaking soybean pods? The math is simple. The annual U.S. soybean harvest is approximately one billion bushels. Of this harvest, 6.6 percent is lost due to shattering of the soybean pods during harvesting. At $2.42 per bushel, the annual loss amounts to $172,440,000.

The University of Illinois at Urbana-Champaign, located in one of the major soybean-growing areas in the world, is seeking the solution to this severe problem. Agricultural engineering Professor D. L. Hoag has a five-year grant to determine the optimal harvesting conditions to reduce soybean shatter. Of the 15 to 20 percent loss of soybean harvest, shattering is the major cause. Stubble loss, stalk loss, and lodge loss account for most of the remaining wastage.

Professor Hoag is studying physical properties of the pod to determine how much impact will shatter the pod. The initial phase of investigation studies the energy absorbed by the pod and the impulse obtained when the beans are struck. The pod is mounted within the swing of a ballistic pendulum. The pendulum is released from a determined distance and swings through the pod, shatters it, and continues to the top of its arc. The amount of energy absorbed by the pod is calculated from the amount of swing lost after the pendulum has passed through the pod. The impulse is measured with a small crystal mounted on the front of the pendulum. This crystal has the property of converting a physical impact into a small electrical charge. Thus, the force needed to shatter the pod correlates with the amount of electric charge measured from the crystal.

The pendulum, a weight of about one and one-half pounds, swings from ten to thirty inches, duplicating the two to three miles-per-hour impact of a combine harvesting the soybeans. Before he could begin his research, Professor Hoag had to arrive at an initial soybean strength. He dropped many soybean pods from various heights to determine at what height they start breaking. The height and weight of the pods set the parameters of the size of the pendulum.

After the physical properties of the bean pods are determined, some cost-benefit analysis will indicate the optimal conditions to eliminate soybean shatter loss. For example, a slower speed combine will break fewer pods — but will the lost time of slower harvesting actually make the operation more profitable? Or, if the beans are harvested at 25 percent moisture to minimize breakage, will the cost of drying them to 13 percent water return a higher or lower profit yield? These very practical problems can only be approached after this initial, basic investigation is accomplished. ●



As the pendulum swings through the soybean pod and shatters it, energy is lost in the impact. This energy is calculated from the distance of swing lost due to the energy absorbed by the pod. Professor D. L. Hoag of the Department of Agricultural Engineering is researching the physical properties of soybeans at the University of Illinois at Urbana-Champaign to determine methods of reducing the $172,440,000 annual loss in the United States due to soybeans shattering during harvest.

UNIVERSITY OF ILLINOIS COOPERATES IN WATER STUDIES

The University of Illinois and Southern Illinois University will cooperate in a laboratory investigation into water research. The four-part project is supported by a grant of $102,000 by the U.S. Department of the Interior, to be matched by state funds under the terms of the Water Resources Research Act of 1965.

Two of the four projects in the study will be conducted at Urbana. W. H. C. Maxwell, Assistant Professor of Civil Engineering, will study "Boundary Effects on Jet Flow Patterns Related to Water Quality and Pollution Problems"; and Earl R. Swanson, Professor of Agricultural Economics, will undertake an "Economic Analysis of Water Use in Illinois Agriculture." ●

THE LANGUAGE BARRIER

Modern electronic computers have demonstrated immeasurable superiority to the human mind in rapidly solving elaborate arithmetic problems, in remembering huge quantities of information, and in retaining and manipulating what they remember. Large computers can remember so many things so very, very well that public attention has been focused on them as a means to give order to the present avalanche of new knowledge.

There is, however, a bottleneck in the usefulness of computers; they insist on being spoken to on their own terms, in their own languages. The computer is not much help to the average person seeking knowledge if he must take the time to learn the computer's language; but the average person has no other choice unless the computer can be taught English. It is this latter problem that the research group led by Professor Robert T. Chien, acting director of the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign, has been trying to solve.

A massive computer program, called simply R2 and referred to as an intelligent, natural language, question-answering system, represents the result of research work supported jointly by the Office of Education and through the Joint Services Electronics Program. The R2 system uses the Illinois automobile driver's manual, *Rules of the Road,* as its body of knowledge consisting of about two thousand English sentences and constituting the largest collection of information incorporated in a system of this type.

English language sentences still do not mean anything to the computer, but their content, in terms of the logical relationships they express, are of basic importance. In dealing with English, then, the computer first must break down the sentence in terms of its structure. Looking very much like the sentence diagramming done by grammar school students, this process, called parsing, indicates the structure of the sentence in a way that is useful to the computer.

These analyzed sentences then are sent on to the second step in the process, called the semantic converter, where the meaning implied by the sentence structure is checked. If the sentence appears to be meaningless, it is returned to be reparsed. If it shows meaningful relationships between its parts, it is translated into a formal, mathematical language and sent on to be processed further.

The last stage in the process is the deduction of an answer to the now formally expressed relationships of the original sentences. Through an advanced logical mathematical procedure, the content of the sentence is processed and combined to arrive at the answer. In returning a response, the computer reconstructs from its formal language an answer in readable English.

This approach to the storage of information is applicable to any collection of knowledge. It has great potential usefulness in searching and retrieving information from the great mass of facts contained in a library record of documents or employed in computer-assisted education. For the computer user, an artificially made language barrier has been broken. ●

U OF I STANDS OUT IN ACE RATINGS

Five departments in the College of Engineering at the University of Illinois at Urbana-Champaign have received high ratings in a recently published poll of college professors conducted in 1969 by the American Council on Education. When assessed totally, the ratings not only show that the U of I engineering departments have maintained or surpassed the positions which they held in a similar ACE survey conducted in 1964, but they also indicate that all five departments have shown significant improvement since 1964.

The council's report is based on questionnaires sent to faculty members in various fields of study at 130 schools. The professors were asked to evaluate the graduate programs at schools that offer doctorates in their respective fields.

The portion of the survey upon which most attention is focused concerns the "quality of graduate faculty." "Quality of graduate faculty" scores could have ranged from a high of 5.00 for a department with a graduate faculty that all raters esteemed "distinguished," to a low of 0.00 for a department with a graduate faculty that all raters considered to be of a quality "not sufficient to provide acceptable doctoral training." An option for "insufficient information" was also provided. In the area of "quality of graduate faculty," the U of I Department of Civil Engineering ranked second. The Department of Electrical Engineering ranked fourth, Chemical Engineering ranked sixth, Physics ranked seventh, and Mechanical Engineering ranked seventh.

These ratings are doubly significant when compared with the findings of the 1964 ACE survey. The Department of Civil Engineering has maintained its second-place position since 1964. However, the department's score has moved up, bringing it to a virtual tie for first place with the University of California at Berkeley. The Department of Electrical Engineering has also held onto its position of fourth place, Chemical Engineering has moved up from eighth, Physics from eighth, and Mechanical Engineering from tenth.

In a second portion of the 1969 survey, the U of I College of Engineering reinforced its position by maintaining a high standing in all of the five departments. This portion concerns the "effectiveness of doctoral programs," and although its importance has been de-emphasized by ACE, its significance should not be diminished when looking at the total outcome of the ratings. The total outcome of the ratings has different meanings in different applications, but to the U of I College of Engineering, it means a job well done. ●

PEOPLE AND PLACES

Professor C. P. Siess, of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign, has been named by the Atomic Energy Commission's Advisory Committee on Reactor Safeguards as its vice-chairman for the calendar year 1971.

William L. Everitt, Dean Emeritus of the College of Engineering at the University of Illinois at Urbana-Champaign, has been chosen to be the recipient of the Washington Award for the year 1971. The Washington Award, named in honor of George Washington, is conferred by the Western Society of Engineers on the recommendation of a commission representing the American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, National Society of Professional Engineers, and Western Society of Engineers. Dean Everitt is the third U of I engineer to receive the Washington Award. Other recipients were **Arthur Newell Talbot**, head of the Department of Theoretical and Applied Mechanics from 1890 to 1926, who was honored in 1924, and **Nathan M. Newmark**, head of the Department of Civil Engineering, who received the award in 1969.

Edward C. Jordan, head of the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign, has been presented with an Ohio State University Centennial Achievement Award. Jordan, an alumnus of Ohio State, received the award at the University's autumn quarter commencement.

University of Illinois Trustee **Ralph C. Hahn** of Springfield has been named to a two-year term on the Small Business Advisory Council. Trustee Hahn, a U of I graduate in civil engineering in 1951, received a master's degree in structural engineering in 1952. He is founder, owner, and principle engineer of Ralph C. Hahn and Associates, consulting and design engineers. On the council he will be an adviser to Springfield area businessmen. ●

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AT URBANA-CHAMPAIGN

inside outlook:

AN APPLICATION OF SYSTEMS ANALYSIS
CIVIL ENGINEERING AFFILIATES PROGRAM
ATMOSPHERIC RESEARCH COOPERATION
A STUDY OF ICE PROPERTIES

SYSTEM FOR SUCCESS

The industrial manager of a developing country, faced with the implementation of large-scale industrialization, finds he has a left-handed nut and a right-handed bolt. The nut: decision-making in a complex process is hampered by scarce resources, lower efficiencies, and the lack of a developed industrial base. The bolt: systems analysis, which can assist him in his decisions, requires math models and digital computers that may not be available.

The double problems of complex systems and developing countries appealed to Professor M. I. Dessouky of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign. His studies into the application of systems analysis to industrial project implementation in developing countries has provided an approach to systems ideally suited to these circumstances. His research, sponsored by the United Nations Industrial Development Organization, is applicable to the three stickiest areas of industrial project implementation: planning, control, and evaluation.

Two important methods will aid planning of complex projects: cost-duration analysis and critical resource scheduling. Cost-duration analysis is a technique which allows the planner to determine the relationship between the total direct cost of his project and the length of time required to complete it. By extending the length of time to complete a project, the careful planner may reduce the cost of a hydroelectric generating plant. But, at the same time, he may deprive his country of an important source of energy for a longer period. Professor Dessouky and former graduate student E. J. Dunne originated a hand-calculated, straightforward analysis which allows the planner to choose the cost and duration which best fits an often tight budget while meeting pressing demands in the shortest time. An important feature of this analysis is that it is a relatively simple technique which does not require a computer.

Critical resource scheduling allows the planner to arrange to distribute skills or materials which are in short supply over the project so that when they are needed, they are available. Heavy equipment necessary to install turbine generators are scheduled so they will not be installing an open hearth furnace in a steel mill three hundred miles south on the same day. It is obvious that critical resource scheduling and cost-duration analysis are not entirely independent. If critical materials are readily available as required, both the cost and duration of the project will be reduced.

Control of a project, after it has begun, is another area which drastically affects the project. If the manager discovers quickly that a vital machine part is incorrectly made, he will have much more flexibility in arranging the remainder of his project. Improved communication and information-gathering generate effective feedback to reduce cost and duration.

Professor Dessouky also explored several different approaches to evaluation of the project and its implementation. A thorough evaluation reveals more than just information on how the project progressed; it also yields vital information on the increasing skills and abilities of the manager.

As a result of his research, Professor Dessouky will devote further attention to two specific problems in the area of project implementation. One study, currently underway, will integrate the cost-duration analysis and the critical resource allocation techniques into one convenient, easily solved "package." Graduate student Charles R. Margenthaler is working with Professor Dessouky on this problem. The second project, which will begin shortly, is the simulation of a complex project. Because of the large degree of uncertainty in many projects, modeling their behavior has been very difficult. A simple and inexpensive simulation can remove some of the uncertainty and also provide the project manager with increased insight into his task.

The final impact of Professor Dessouky's research will be difficult to measure exactly, but his results will help developing countries develop a bit sooner. ●

OUT OF THE IVORY TOWERS

Civil engineers, who are experts in these matters, assure us that an ivory tower is not an appropriate foundation for a college of engineering, either structurally or philosophically. In recognition of this fact, the Department of Civil Engineering and the College of Engineering of the University of Illinois at Urbana-Champaign have introduced a new program in University-industrial cooperation to foster a closer working relationship between the engineers of industry and the members of the U of I faculty.

In recent years, important new developments have brought about radical changes in the industries that have a strong reliance on civil engineering. The Department of Civil Engineering at the U of I has played a substantial role in this progress. As the products of our efforts at the University emerge at a quickened pace, it is necessary also to speed their communication to the potential user. In this way, they are put to the test in actual practice as soon as possible. It is equally important to recognize that the quality of our educational programs and graduates depends upon a good understanding of the changing and expanding requirements of industry.

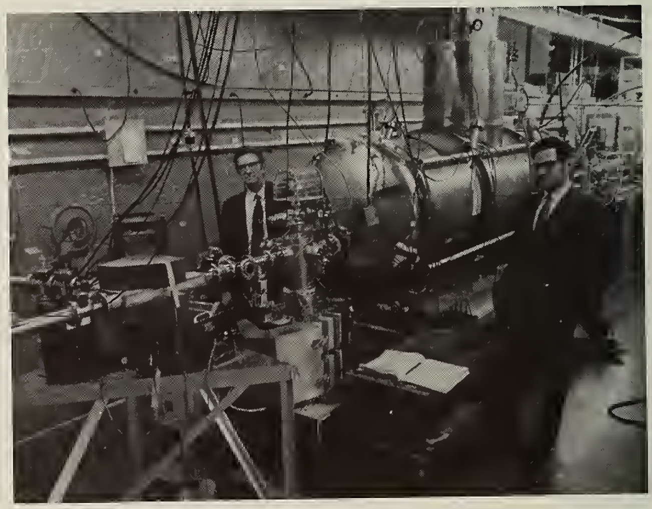
The Affiliates Program in Civil Engineering was established to meet these needs. The program will enhance interaction between industry and the University through an advisory committee, an annual workshop, and visits between industry and faculty.

Each affiliate will appoint a representative to serve on the advisory committee. The discussions and recommendations of this committee, which will meet annually, should produce valuable insights into the future trends of civil engineering and civil engineering education. These meetings will afford affiliates the opportunity to influence the trends in education and research and provide meaningful inputs to educational programs for civil engineering students.

An annual workshop of representatives of the affiliated organizations will review current research projects at the University. These workshops will stress the implications of the research and their application to practice. During the workshop, representatives will have the opportunity to visit the laboratories and become personally acquainted with current research activities and the faculty members and graduate students working in the various areas of civil engineering.

Engineers and research workers of the affiliated organizations are also encouraged to visit the University and faculty at other times to discuss problems and areas of mutual interest. In addition, visiting civil engineering executives could share their experience with faculty and students through a series of formal or informal lectures and seminars. A faculty member or members with interest close to those of the affiliated organization will visit the affiliate at least once a year to discuss the program and present appropriate findings of research to groups in the sponsor's organization.

By continuing this close interaction, both the University and industry will profit. Through an exchange of knowledge and discussions, the affiliates will have a closer, more personal access to the civil engineering research and faculty. And, by providing insight into the needs of industry, the affiliates can help make the University more responsive to the needs of industry. If you feel your organization may wish to participate, contact Dr. N. M. Newmark, Head, Department of Civil Engineering, University of Illinois, Urbana, Illinois 61801. Then your organization can join with us in replacing ivory towers with bridges between industry and the University. ●



Physics professors A. O. Hanson (left) and Peter Axel with the superconducting linear accelerator, or LINAC (*Outlook*, September 1968), of the University of Illinois at Urbana-Champaign, which has just passed a major test of construction. On its first trial, with three of the machine's 16 electrodes in place, all components operated with excellent control with the "atom-smasher" producing a sharply focused electron beam of more than one million volts energy. Operating the electrodes at 456° below zero requires only one one-millionth of the power needed at room temperature.

ATMOSPHERIC RESEARCH IS LOOKING UP

The University of Illinois at Urbana-Champaign has been elected to membership in the University Corporation for Atmospheric Research. Created in 1959, the corporation has established the National Center for Atmospheric Research at Boulder, Colorado, to conduct long-term scientific programs, with the ultimate goal of helping solve human problems related to weather, water, and climate. The center is sponsored by the National Science Foundation. Center activities augment the work of university research programs by providing joint-use facilities, and its staff works with university scientists and engineers to stimulate a broader intensive atmospheric research effort in universities. ●

A COLD, HARD LOOK AT ICE

If, by some fluke of man or nature, there is a power failure on the campus of the University of Illinois at Urbana-Champaign, eighteen months of preparation for a research project in the U of I Materials Research Laboratory will literally go down the drain. As every housewife knows, a power failure will melt the ice in her refrigerator. And so it will in a refrigerated laboratory used by geology Professor Jon Holder and physics research assistants Fred Mackie and Dave Joncich to form ice crystals for their research program concerned with determination of the thermal and mechanical properties of solids.

Basically, the program is an interdisciplinary effort and draws on the earlier research of physics Professor A. V. Granato and research assistant R. O. Schwenker, which involved the reradiation of sound waves from thin layers of oscillating dislocations in sodium chloride crystals. Of primary interest to Professor Holder is the electrical charge density associated with dislocations in ice. The first step in the project was the development of the necessary apparatus and techniques for growing ice crystals. After the apparatus and techniques were developed, the ice crystals had to be grown and stored.

It takes approximately one and one-half months to grow one ice crystal which can be used in the project. Growth of the ice crystal begins with a plastic bag of tap water. The water is frozen and then repeatedly zone refined — a process which entails lowering the bag through a heater. A layer of water is melted in the bag, causing the impurities to rise from the ice into the water. The resulting pure crystal is approximately three inches thick by three feet long.

When the crystal is fully grown, cubes are cut from it. Dislocations are formed in the cubes through a process called three-point bending which involves the application of knife pressure to the center top and two end bottom points of the cube. At present, attempts are being made to turn out crystals with dislocation walls. Once a sufficient supply of crystals is produced, the measurement of their properties will begin.

Professor Holder and his research team will attempt to take a look at dislocations in ice through the use of ultrasonic high frequency sound waves. Dislocations in ice seem to be charged, and when the dislocation is moved or oscillated, the charge will move with it. A sound transducer which converts an electronic pulse into a mechanical pulse will be placed on the ice and oscillations will be excited ultrasonically. An ultrasonic frequency of ten million cycles per second will be used, and it is not yet known whether or not the use of such a high frequency will be successful. Detailed motions of dislocations can be seen through the measurement of sound wave properties. Ultimately, Professor Holder hopes to find out the detail, magnitude, and mechanism of charge distribution and how these affect dislocations in ice.

Barring an unscheduled thaw, Professor Holder's research will move into full gear in the near future, and if successful, it will provide a deeper understanding of the mechanical and thermal properties of solids. ●

POTPOURRI

The University of Illinois at Urbana-Champaign ranks second only to the Massachusetts Institute of Technology in the number of alumni among 1500 names in "Engineers of Distinction," published by the Engineers Joint Council. MIT leaders in their profession number 74, those from Illinois number 68. The compilation of "engineers who have assumed leadership roles in the profession" was limited to "winners of national awards and officers, directors, and chief staff officers of national engineering societies."

A two-year, $151,000 research grant has been awarded to the University of Illinois at Urbana-Champaign by the National Science Foundation for a project in the Department of Civil Engineering. The project aim is to mathematically reproduce earthquake motions with a computer so effects of local geology may be studied and incorporated into the design of earthquake-resistant buildings. Research directors are Professor Nathan M. Newmark, Head of the Department of Civil Engineering, and Professor Leonard A. Lopez.

Forty high school juniors will explore the fields of science and engineering during a six-week program, June 21–July 31, at the University of Illinois at Urbana-Champaign. The National Science Foundation has announced a $15,726 grant to support the twelfth annual Pre-College

Student Science Training Program directed by Professor Jerry S. Dobrovolny, Head of the Department of General Engineering, with Professor David C. O'Bryant as associate director. The award brings to $168,744 the total which NSF has provided for the program since 1960.

Three engineering departments at the University of Illinois at Urbana-Champaign have received grants from the 1971 educational aid program of the Du Pont Company, Wilmington, Delaware. The Department of Chemical Engineering has received $10,000; Mechanical Engineering, $5,000; and Physics $5,000. The purpose of these grants is to allow the departments to undertake work which otherwise would not be possible. The University decides how funds are used. ●

PEOPLE AND PLACES

John Bardeen, Professor of Physics and Electrical Engineering at the University of Illinois at Urbana-Champaign, has been elected by the Institute of Electrical and Electronics Engineers to receive its medal of honor. In 1956 Professor Bardeen shared the Nobel Prize in physics for invention of the transistor. The IEEE has cited him "for his profound contributions to the understanding of the conductivity of solids, to the invention of the transistor, and to the microscopic theory of superconductivity." Professor Bardeen is the second person from the University of Illinois to receive the IEEE award. In 1956 it was presented to **William L. Everitt,** now dean emeritus of the College of Engineering. In 1965 Professor Bardeen received the National Medal of Science. He is a member of the National Academy of Science, American Philosophical Society, and American Academy of Arts and Sciences, and a fellow of the American Physical Society of which he was president in 1968–69.

Roy D. Schermerhorn, a sophomore in mechanical engineering, has been named to a 1971–72 exchange scholarship between the University of Illinois at Urbana-Champaign College of Engineering and the Technical University at Munich, Germany. Earlier, **Robert S. Bretzlaff,** a junior in physics, had been named to an exchange scholarship at Munich. Bretzlaff and Schermerhorn will be the fourth and fifth U of I students in a program which previously had been limited to one student each year. Schermerhorn is a James Scholar at the University and is now taking honors courses in computer science and mechanical engineering.

Automated Procedures for Engineering Consultants has awarded honorary membership to Professor **Wilbert F. Stoecker** of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign. APEC is an association of consulting engineers who have banded together to promote the use of computers in their engineering practice. Stoecker was cited for his contributions to methods for simulating air conditioning systems, an important step in estimating energy consumption of the systems. ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 12, NO. 8, APRIL 1971

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AT URBANA-CHAMPAIGN

inside outlook:

STUDY OF THE UPPER ATMOSPHERE
HYDRAULIC NOISE SUPPRESSION
VOCATIONAL AND TECHNICAL COURSES STUDIED
RURAL INTERSECTION ILLUMINATION
CERAMIC CINEPHOTOMICROGRAPHY

WHAT'S UP

Preliminary engineering studies are underway at the University of Illinois at Urbana-Champaign for a proposed $12- to $15-million Upper Atmosphere Observatory to study relations of space energy to weather, radio communications, and other phenomena on earth. A team of project consultants from the United States and Canada is headed by Professor Sidney A. Bowhill of the Department of Electrical Engineering.

The tentative site for the observatory is near the central or eastern Canadian border, where, because of the earth's magnetic field, ionized layers of the upper atmosphere form a low-density "trough" offering opportunity for a variety of research activities not possible elsewhere. To study winds and ionospheric disturbances 50 to 6000 miles above the earth, the observatory will use incoherent scatter radar, a new system developed within the last ten years. The system's very high-powered signals can track and study rarefied gases and particles at extreme altitudes.

Support and use of the observatory will be international, with a strong research and educational program involving resident and visiting scientists and graduate students. Preliminary engineering studies are being done under a $99,950 National Science Foundation grant to the U of I. Completion of the studies is expected by July 1, and the timetable anticipates federal funding decisions by the end of the year. Completion of the observatory is planned for mid-1974. ●

SOME SOUND RESEARCH

Does a tree falling in a forest really make a sound if there is no one there to hear it? Philosophers have debated this question for centuries, but there is little question about noise when there is someone around to listen. And the noise made by a typical hydraulic system is usually loud enough to drive even a stoic to purchase a pair of earmuffs.

These hydraulic systems can be found everywhere: on small garden tractors, on large earth moving equipment, and in numerous other industrial applications including a wide variety of machine tools. And wherever they are used, there are people nearby exposed to their deafening clatter. How can this noise be eliminated, or at least minimized? This is the problem being studied by Professor J. M. Robertson and research assistants C. F. Holt and T. J. Labus in the Department of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign. Their research, sponsored by Sundstrand Aviation, is attempting to get at the source of noise in hydraulic systems.

Professor Robertson and his research team are looking at a specific kind of hydraulic system — one driven by a piston cylinder pump. They feel that the pressure waves in these pumps are the basic source of noise. A small amount of the power transferred by the pumps, when diverted from useful work, can produce a great deal of noise. The high-pressure oil flow into cylinders as they are opened is now being studied, and pressure changes are being evaluated rather than the amount of noise produced.

Actually, Professor Robertson's research is rather quiet, considering the subject. A digital computer is used to calculate the pressure wave occurrences and evaluate the effect of each change in the system on the piston loading. Additional work is being done with a water table, which produces waves in a shallow body of water analogous to pressure waves in a fluid such as oil. Through the use of photographs and measurement of wave depth, the researchers can study waves as they move from one end of the table to another, bouncing against and loading a simulated piston. In an actual hydraulic system, a high rate of loading on the piston causes vibration of mechanical parts and noise. Professor Robertson is hoping to find out what influences the load on a piston and therefore what affects the production of noise.

Currently the researchers are designing a piece of equipment which will simulate the operation of a cylinder, allowing them to measure pressure pulsations and to view internal flow resulting from projected changes in the hydraulic system. This equipment should be in operation in about a year and should offer a good technique for figuring out whether noise can be reduced with various proposed hydraulic system refinements. If they are successful, noisy hydraulic systems should become a problem heard only in the past. ●

ELECTRONICS TECHNOLOGY COURSES CHARTED

Vocational and technical students cannot be taught effectively in the same class: they have different objectives and interests and should have separate courses. This conclusion, which can be applied in many fields, is the result of a two-year study which centered in the Department of General Engineering at the University of Illinois at Urbana-Champaign and in the classrooms and laboratories of Parkland College, Champaign.

The study, which involved six other Illinois junior colleges besides Parkland, investigated basic factors essential to developing laboratory and classroom materials and programs for two-year electronics technology training in junior colleges. It was financed by a $183,170 National Science Foundation grant and involved an eight-week institute held at the University of Illinois at Urbana-Champaign last summer in which twenty-four junior college electronics teachers from across the nation evaluated and contributed to the project report.

The report presents teacher's guides for seven courses in the electronics technology curriculum. An initial introductory quarter for all students in electronics, after which they split into two parallel series of courses, is recommended in the report. Those interested in an electronics technology associate degree go through a two-year series with technical emphasis; those interested in a vocational electronics diploma or certificate take a shorter series with vocational emphasis.

Professor Daniel S. Babb of the Department of Electrical Engineering of the University of Illinois at Urbana-Champaign directed the project, and Professor Jerry S. Dobrovolny, head of the Department of General Engineering, was project advisor. ●

PROCEEDINGS DIG INTO HIGHWAY SOILS

Twentieth Annual Highway Geology Symposium, proceedings of a symposium held in April 1969 at the University of Illinois at Urbana-Champaign, has been published by the U of I Engineering Publications Office. The symposium, sponsored by the U of I Departments of Civil Engineering and Geology, the Illinois Division of Highways, and the Illinois State Geological Survey, covered such topics as "Soils of Illinois and Their Engineering Characteristics," "Fracture Surfaces of Carbonate Aggregates: A Scanning Electron Microscope Study," and "Seismic Mapping of Cavities and Voids." The proceedings may be purchased for $3.00 from the Engineering Publications Office, University of Illinois, 112 Engineering Hall, Urbana, Illinois 61801. ●

LET THERE BE LIGHT . . . BUT NOT TOO MUCH

Since 1558, when street lighting was first introduced in Paris to combat crime, roadway illumination designers have generally felt that if some light were good, then more was better. While this may be true in an urban setting, investigators at the University of Illinois at Urbana-Champaign are questioning this assumption when it is applied to the most frequent type of Illinois road situation — the rural intersection.

Their problem is a thorny one: With only limited funds for roadway illumination, which intersections require lighting and what type of lighting do they need? Present lighting practice is largely after the fact; when a rural intersection shows a high night-time accident rate, then it is lit. Standardized illumination installations are often used without questioning the types of lighting that may be required.

Under the direction of civil engineering instructor M. E. Lipinski and Professor R. H. Wortman, the Illinois research group is developing techniques to identify rural intersections which need lighting and to determine the level and type of illumination needed. They began their study at a point often overlooked by previous researchers — the driver. Although lighting is part of the total roadway design, its ultimate goal is *not* to illuminate the roadway, but to provide the driver with enough visual information so that he can negotiate the intersection with maximum safety and efficiency.

They discovered that the driver uses lighting in two ways: for increased visibility and for visual cues of approaching changes in the driving environment. When seen from the driver's point of view, too much light may be as bad as too little light. An over-abundance of light may produce glare which blinds the driver. It may reduce the shadow of a median curb so much that it is difficult to see. Especially at rural intersections, a high level of light may blind the driver to possible hazards in the road just beyond the lighted portion of the roadway. Lower levels of illumination may serve as an "attention getter," which notifies the driver of a hazardous road situation rather than making it more visible. A single light which may not completely illuminate the intersection can draw attention to an unsuspected crossroad.

Illumination, regardless of level, may not be the sole cause of after-dark accidents. As the sun goes down, driver fatigue and the percentage of intoxicated drivers on the road tend to go up. Improperly placed signs or poor roadway construction may also play a part in an increased accident rate. Although improved lighting practices can reduce the accident rate, Lipinski and Wortman caution that simply adding more lighting without regard to other factors is not a panacea. Lighting should be weighed against other possible improvements to the intersection. They emphasize the need for an integrated approach to rural intersection lighting. For proper design, they recommend that, in addition to roadway designers and illumination specialists, human factors experts be included in the design team.

In future study, they hope to discover exactly which characteristics of rural intersections demand illumination and which do not. By knowing these characteristics, designers can include appropriate lighting in the original roadway design instead of waiting for a series of accidents to demonstrate the need for lighting. The acid test of their findings will come when they are applied to the thousands of Illinois rural intersections. When they do, Lipinski and Wortman hope they shed some light on the murky area of rural intersection illumination. ●

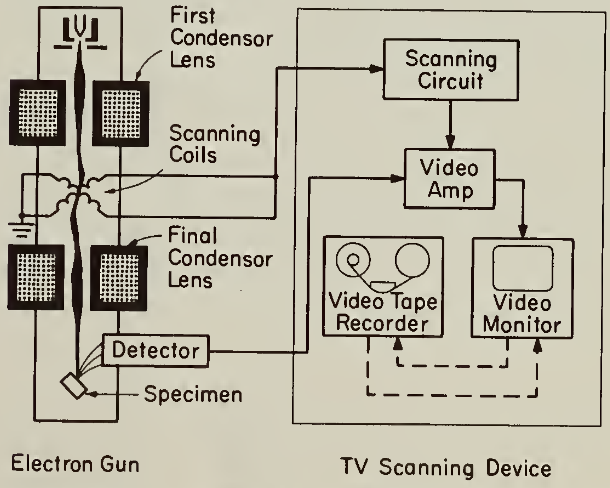
LIGHTS, CAMERA, ACTION

A television special entitled, "Hot SEM Time Lapse Cinephotomicrography," probably would not fare too well in the Nielsens. But a project with the same title, produced and directed by a professor in the Department of Ceramic Engineering at the University of Illinois at Urbana-Champaign and one of his former students, now a professor of ceramic engineering at the University of California at Berkeley, will always have an audience, even if it may be a select group of engineering students. The project, undertaken by U of I Professor Alfred W. Allen and U of C Professor Richard Fulrath, involves a unique type of "movie" that is now being featured as a teaching aid in ceramic engineering classes.

The real star of the show is the scanning electron microscope (SEM). Without the SEM, the project would not have been possible. Its unusual features, including a wide range of magnifications (from 20 to 20,000x) and great depth of field, make it a perfect tool for viewing ceramic microstructures. But the key to the project is the television scanning device which can be hooked up to the SEM. Through the use of this device, the signal that produces the microscopic image can be converted to a video signal. Professors Allen and Fulrath have carried the process a step further. They have used a video tape recorder to make time-lapse "movies" of a heated specimen, thus offering their students a chance to see something no one has ever seen before — the actual changes which occur during sintering: creation of an imporous mass through heating of a powdery substance.

To show the sintering process, professors Allen and Fulrath enclosed their specimen in a furnace-type structure. This is the first time the SEM has been used with a heated specimen. In demonstrating the densification of ceramics such as nuclear fuels, they used microspheres of nickel which were heated to 1400°C. Time lapse "movies" were taken of the sintering process, which is not visible to the naked eye. The resulting video tape films enable a class in ceramic engineering to watch the microspheres go together in a time period of 15 to 20 minutes. They can actually see what they already "know" in mathematical terms. Also, they can see how the actual process may differ from mathematical models. This has not been possible in the past because sintering was always viewed after the fact.

Plans are underway for professors Allen and Fulrath to continue production of their feature films. So ceramic engineering students at the U of I can look forward to more time at the flicks, and even though they will have to bring their own popcorn, admission will be free. ●



This diagram of the scanning electron microscope shows how SEM units can be equipped with a TV monitor which can display rapid transformations in a specimen. The scanning system in this device is the same as the standard TV system, enabling a conventional video tape recorder to be used for recording and reproducing the image. Professor Alfred W. Allen of the Department of Ceramic Engineering at the University of Illinois at Urbana-Champaign and his former student Richard Fulrath have used SEM movies to show the densification of ceramics.

"CONSTRUCTO" IS FOURTEENTH IN RESEARCH SERIES

The fourteenth report in a series relating to construction research in the Department of Civil Engineering at the University of Illinois at Urbana-Champaign has been published by the Engineering Publications Office. Entitled "Constructo: A Computerized Construction Management Game," the report details a computer program designed to teach construction management to managerial trainees (*Outlook*, November 1970). The program is set up so that the trainee can get the feel of being in charge of a construction project. It was developed by civil engineering Professor R. W. Woodhead and graduate student D. W. Halpin.

Included in the appendices of the report are examples of both input and output for several construction projects, a procedural word hierarchy, and charts for environmental factors. Copies of *Construction Research Series No. 14*, "Constructo: A Computerized Construction Management Game," by D. W. Halpin and R. W. Woodhead, are available for $3.00 from the Engineering Documents Center, 208 Engineering Hall, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

Three students in the College of Engineering at the University of Illinois at Urbana-Champaign have received $500 scholarships from the Foundry Educational Foundation in recognition of their interest in the cast metal industry. They are **Rodney W. Rieger, David Williams,** and **Gary Smith,** all students in foundry science courses under Professor James L. Leach of the Department of Mechanical and Industrial Engineering. Rieger and Smith will be graduated from the University in June and Williams next February.

The College of Engineering at the University of Illinois at Urbana-Champaign presented its Alumni Honor Awards for Distinguished Service in Engineering at the April 30 College Convocation. The awards are given to alumni or former staff members who have distinguished themselves by outstanding leadership in planning and direction of engineering work, by fostering professional development of young engineers, or by their contributions to knowledge in the field of engineering. This year's award winners are: **Earl Henry Beling,** owner, Beling Engineering Consultants, Moline, Illinois; **William Littell Everitt,** dean emeritus, College of Engineering, University of Illinois at Urbana-Champaign; **Jack St. Clair Kilby,** assistant vice-president, Texas Instruments, Inc., Dallas, Texas; **Lester Clyde Lichty,** Robert Higgins Professor of Mechanical Engineering, emeritus, Yale University, New Haven, Connecticut; **Ralph G. Nevins,** dean, College of Engineering, Kansas State University, Manhattan, Kansas; and **Frederick John Schlink,** president and technical director, Consumers Research, Inc., Washington, New Jersey. ●

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VOL. 12, NO.9, MAY 1971

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AT URBANA-CHAMPAIGN

inside outlook:

O'HARE TO MIDWAY TRANSIT SYSTEM
HIGHWAY VEHICLE FOR QUADRIPLEGICS
SUMMER STUDIES FOR CIVIL ENGINEERS
URBAN VEHICLE DESIGN COMPETITION

FIVE MINUTES TO MIDWAY

Even before Emerson uttered those immortal words about a better mouse trap, men were striving to come up with innovations that would enable them to live more efficiently. Today, with our overcrowded cities, overloaded transportation systems, and polluted environment, there is a constant need for new ideas that will help us to improve our quality of life. Two alumni of the University of Illinois at Urbana-Champaign came up with a "better mouse trap" last year while they were seniors in the Department of General Engineering, and the world has been beating a path to their doors.

Andris Maneks, now working for Factory Mutual Engineering Association in Chicago, and James H. Harris, now with Schlumberger Technology Corporation, an oil well logging firm in Houston, Texas, have received wide recognition for their design of a high-speed transportation system between O'Hare International and Midway airports in Chicago. Maneks and Harris undertook the design project in an attempt to find a way for more effective and greater utilization of Midway Airport. If Midway could be utilized to its capacity, most of the smaller airline traffic could be transferred there, thus relieving the overcrowded conditions at O'Hare. It was decided that a high-speed transportation system to transfer passengers and baggage between Midway and O'Hare would solve the problem, and the feasibility of such a system was studied.

Various modes of high-speed ground-level transportation were investigated but ultimately rejected because of right-of-way problems which would be encountered in the densely populated area between the two airports. The solution to the problem appeared to lie with High-Speed Ground Transportation or HSGT vehicles designed to travel over 200 mph in an underground configuration. Of the many HSGT systems proposed, the Gravity-Vacuum Transit (GVT), which derives two-thirds of its power requirement from gravity and one-third from pneumatic pressure to attain a maximum speed of 225 mph, was chosen because a great deal of information on the system is available.

The GVT system, developed by the Tube Transit Corporation of Palo Alto, California, travels inside an evacuated tube. Steel wheels on steel rails are the means of suspension. As a train leaves a station, it travels down a slope and is accelerated by gravity as potential energy is converted to kinetic energy. As the train approaches the next station, it travels up a slope to the same elevation as the first station. In ascending the slope, the train is decelerated by gravity as kinetic energy is reconverted to potential energy, and the train comes to a natural stop at the station without the use of brakes. Supplementary propulsion is provided by pneumatics which overcome losses due to windage and rolling friction and increase the speed of the train. A travel time of 4.5 to 5 minutes at a tunnel depth of 2000 feet is indicated for the O'Hare to Midway route of 15.2 miles. Maneks and Harris modified the original GVT proposal for the use of two tubes and specified one tube, substantially reducing the system cost.

Over two-thirds of the cost of implementing an underground transportation system would be the tunnelling cost. Maneks and Harris completed a study on tunnelling and recommended the use of moling machines for the Chicago area. Other aspects of the project studied included terminal location, excavation and design of terminals, the handling of baggage, and financing. Each detail of the projected system was worked out, and it was finally recommended that the initial costs be financed through the issuance of revenue bonds.

Design of the O'Hare to Midway system has won second place for structures in the 1970 Engineering Student Design Competition sponsored by the James F. Lincoln Arc Welding Foundation. This award carries a $1,000 cash prize, to be divided between Maneks and Harris, and $300 for the U of I Department of General Engineering. General engineering Professor Bernt O. Larson was principal consultant for the project, and Edward S. Frazer, U of I alumnus and vice-president of research, Chicago Bridge and Iron Works, served as industrial adviser.

Last July, Maneks delivered a live presentation on the project to the American Society of Civil Engineers at its Boston National Transportation Engineering meeting. This was the only undergraduate presentation invited to the meeting. A half-hour videotape of the design for the proposal had already been presented to Chicago Mayor Richard Daley and his staff.

Although the O'Hare to Midway GVT system still only exists on paper, Andris Maneks and James Harris have had the vision to solve a difficult problem and to show how that solution will work. The recognition that they have received for this project is possibly only the beginning of a well-beaten path to their doors. ●

LEVER THE DRIVING TO US

Often engineering research does not appear germane to the individual's problems. Graduate research assistant George Stupp is designing an optimum driving control system to minimize the required effort and emphasize the communication from the driver to his vehicle as an important aspect of control. As a result, a highway vehicle will be able to be controlled by a small, finger-actuated lever operated by individuals like George who have severe impediment of their limbs and are confined to motorized wheelchairs.

Under the direction of H. W. Knoebel, Professor of Aeronautical and Astronautical Engineering and Research Professor of the Coordinated Science Laboratory, a highway vehicle is being designed and prepared for independent use by quadriplegics. The program consists of two major components: development of the vehicle itself, including systems for entry, exit, body restraint, and power actuation of controls; and the internal transfer model of the steering control.

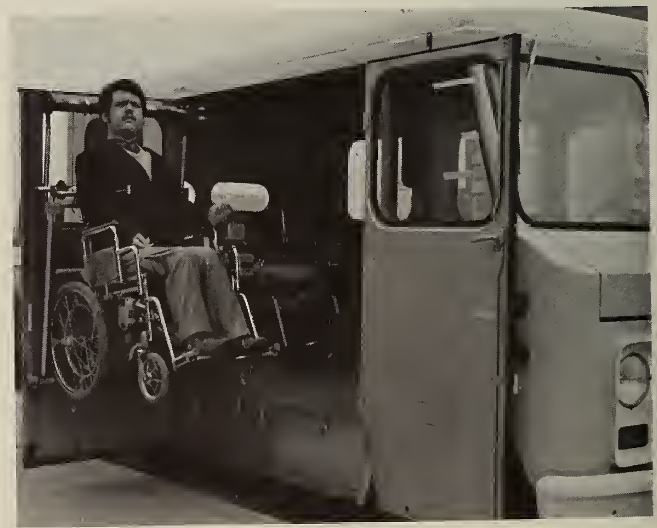
Since independent movement from a wheelchair to a driving seat is impossible, Knoebel's group designed a chair-lift mechanism that will enable the chair to be lifted into the van. The chair is backed against the lifting bar which engages the chair handles and raises the chair by hydraulic actuation. The van doors are also open and shut by hydraulic action. A small panel controls these entry and exit mechanisms. The new lift mechanism is superior to the conventional platform lift in both safety and ease of operation. It is aesthetically more acceptable than the platform lift, being unobtrusive when not in use.

A step van has been donated by General Motors for the project. It is the smallest standard commercial vehicle which provides sufficient headroom for independent access by a person in a wheelchair. The lift has already been built into the door of the van.

A two-speed rate control system that is both simple and dependable will be used for steering. It overcomes the difficulty of a single-rate mechanism which would be too unstable during high-speed driving and too sluggish for slow-speed corner-turning or parking. The double system serves as a safety device, providing a back-up alternative steering control. The throttle-brake system is also a two-rate mechanism for high and slow accelerations and decelerations. Both speed and steering control will be accomplished through the small stick lever.

The driver's console is being designed by two general engineering undergraduates to accommodate and secure a motorized wheelchair for optimum vision and control. Power actuation of the controls is also being developed. A lack of funds, however, has stopped the physical modification of the van.

Therefore, with the designs fairly complete, only financing stands in the way of freeing those confined to wheelchairs by the present limitation of distance. Once the project gets underway again, jobs and leisure will no longer have to be within "wheeling" distance of home. ●



Research assistant George Stupp of the Coordinated Science Laboratory of the University of Illinois at Urbana-Champaign operates the door lift that permits independent access to the van for an individual in a wheelchair. The small control box not only operates the lift, but opens and closes the van doors.

SUMMER SCHOLARS

Eight students now in their junior year in civil engineering at the University of Illinois at Urbana-Champaign will have a unique opportunity to carry on research under an $11,790 National Science Foundation grant just received by the University.

The grant, to be administered by Professor LeRoy T. Boyer, will enable each student selected to devote full time for 12 weeks this summer to research under a senior member of the civil engineering staff. In the semester preceding the summer experience, the student will devote part time to planning and preparing the research, and in the following semester, part time to preparing a report on his work.

The first student experience project of this type at the U of I was in the summer of 1959, and similar projects under NSF support have been carried out every summer since. ●

BUT WHERE WILL THEY PARK IT?

Although the automobile is still king of the open road, in an urban setting it resembles a bull in a china shop, causing headaches for drivers, pedestrians, and city officials. But it is one thing to recognize the problem created by cars in an urban situation and another thing to do something about it. College, university, technical institute, and high school students throughout the United States are attempting to solve the problem through participation in the Urban Vehicle Design Competition (UVDC). And the Urban Vehicle Design Group of the University of Illinois at Urbana-Champaign is enthusiastically preparing an entry.

The Urban Vehicle Design Competition is being coordinated by a national committee selected and approved by members of the Clean Air Car Race Committee, which was organized at the Massachusetts Institute of Technology to sponsor the first Clean Air Car Race. The Clean Air Car Race was designed to emphasize automotive emission control. Though the entries were scored on many other factors, the emission score was the most crucial. The UVDC is a natural extension of the Clean Air Car Race aimed at an urban situation: city driving and city parking. Entries into this competition must be designed primarily for use in urban centers of the 1980s, and scoring will be in such areas as emissions, safety, production cost, handling, acceleration, braking, noise, turning circle, parkability, driveability, space utilization, and energy efficiency. Unlike the Clean Air Car Race, the UVDC will not be a cross-country race.

U of I students began to show interest in the UVDC late last year, and as a result, the Urban Vehicle Design Group was formed. The group is made up of representatives from four engineering society student branches: Society of Automotive Engineers, Institute of Electrical and Electronics Engineers, Illinois Society of General Engineers, and American Society of Mechanical Engineers. Tom Quaka, a senior in mechanical engineering, is general project coordinator and chairman of the group's board. Don Keene, a junior in mechanical engineering, is doing liaison work with the national UVDC committee. Group advisors are Professor Spencer Sorenson of the Department of Mechanical and Industrial Engineering, Professor Richard Klein of the Department of Mechanical and Industrial Engineering, Professor L. Daniel Metz of the Department of General Engineering, and Professor Roger Burtness of the Department of Electrical Engineering. Work on the prototype models will be done by volunteer students under the auspices of the group.

Early work on the competition entry included formation of committees to study possible power plants, body and chassis design requirements, braking, and safety considerations. Open seminars were held with representatives from industry present to discuss various types of power plants. Preliminary proposals for entries were prepared by groups of students working either for course credit or on their own, and the Urban Vehicle Design Group's governing board has chosen two of these proposals for submission to the national UVDC committee on July 1, deadline date for detailed design proposals.

One proposal calls for construction of a vehicle of the hybrid design, which incorporates a small internal combustion engine — operating in a very low pollution mode — to recharge the batteries which power the electrically driven vehicle. The second proposal involves the use of a Wankel engine with equipment as needed to derive the lowest possible emissions. An automatic transmission and compact-sized body are being considered for use with the Wankel engine.

Since the UVDC is envisioned as a two-stage effort — first a design project and second a prototype competition — the Urban Vehicle Design Group has a double task ahead of it. Design proposals must be presented at a national symposium, to be held in August. The symposium has been set up to provide an opportunity for the entrants to assess each other and to be judged on the quality of their work to date. If funds become available to the national UVDC committee, some grants will be awarded at this time, based on the quality of design proposals.

Actual work on the group's prototype models should get underway shortly, and it is hoped that various industrial sponsors can be found to aid in the project. The prototype stage of the competition is scheduled for August 1972. If all goes well, the urban car you purchase in 1981 may have had its first test run on the Urbana-Champaign campus of the University of Illinois in 1971. ●

PEOPLE AND PLACES

The tenth and eleventh members of the faculty in the University of Illinois at Urbana-Champaign have been elected to membership in the National Academy of Engineering, the highest professional distinction which can be conferred on an American engineer. They are **Sidney A. Bowhill**, Professor of Electrical Engineering, and **John C. Frye**, Chief of the Illinois State Geological Survey and Professor of Geology.

Professor **Paul A. Beck** of the Department of Metallurgy and Mining Engineering at the University of Illinois at Urbana-Champaign has been honored by the designation of Fellow by the American Society for Metals. ASM established the honor to provide recognition to members for distinguished contributions in the field of metals and materials and to develop a broadly based forum for technical and professional leaders to serve as advisers to the society.

The Executive Board of the University of Illinois Mothers Association has nominated **Barbara Crawford Johnson** (Mrs. Robert) to receive their 1971 Medallion of Honor Award. She is the Engineering Manager of Missions Requirements and Evaluation, CSM System Engineering-Research, and Engineering and Testing with North American Rockwell Corporation's Space Division, located in Downey, California. Mrs. Johnson was the first woman to graduate from the U of I Department of General Engineering (1946) and holds the highest position held at the Space Division by a woman. She is supervisor of the unit responsible for spacecraft earth reentry as well as being in charge of additional vital systems of monitoring and assuring the space crews while in flight.

David R. Opperman, assistant dean in the College of Engineering of the University of Illinois at Urbana-Champaign, has been elected vice-chairman of the Cooperative Education Division of the American Society for Engineering Education. He assumes his new post July 1. Currently he is a member of the society's executive board and program chairman for the annual meeting, to be held June 21–24 at Annapolis, Maryland. Dean Opperman also is chairman of a joint committee of the division and the Cooperative Education Association.

Professor **Nathan M. Newmark**, Head of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign, has been presented with the Outstanding Civilian Service Medal of the Department of the Army. Newmark was honored "for distinguished performance as a consultant and as a member of consultant boards to the United States Army Corps of Engineers from 1946 to 1970." ●

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engineering outlook

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 12, NO. 10, JUNE 1971

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inside outlook:

STUDENTS INVESTIGATE PACKAGING
SPRING RESPONSE THEORY DEVELOPED
NEW RADIO TELESCOPE INITIATED
FRACTURE MECHANICS CONFERENCE SLATED

IT'S IN THE BAG — OR BOTTLE, OR CARTON

This fall a group of students at the University of Illinois at Urbana-Champaign will be wrapping up twelve weeks of summer research on a serious environmental problem: the effect of food and beverage packaging on household wastes. The project is unique in two respects. It is a totally interdisciplinary effort being carried out by fourteen students from eight different areas of study, and it is supported by the first grant to the U of I under the new National Science Foundation student-originated research program. Participating students will receive a stipend, and the University's facilities will be available to them for the summer.

Emphasis is on student research, with faculty members acting in an advisory capacity. Project directors are Dale Jurich, a senior in electrical engineering and computer science, and Richard Frederick, an undergraduate biology student. Faculty advisors are Professor John T. Pfeffer of the Department of Civil Engineering and Professor William R. Boggess, Head of the Department of Forestry.

The project proposal, entitled "An Investigation of the Long Term Effects on Society of Alternative Methods of Packaging Food and Beverages for Household Consumption, and of the Associated Packaging Usage Patterns," grew out of an interdisciplinary honors course in which students are studying problems of technology and the environment. Objectives are to develop information to evaluate packaging and, through interdisciplinary research, find methods for handling solid-waste environmental problems.

Using the American household as a base, the students plan to investigate the feasibility of alternatives to present packaging methods. They will canvass housewives for opinions about packaging and will use the University's computer facilities to analyze answers. Recycling of materials — as is being done in some places with glass, metal, and paper — is among the waste-reducing methods to be studied.

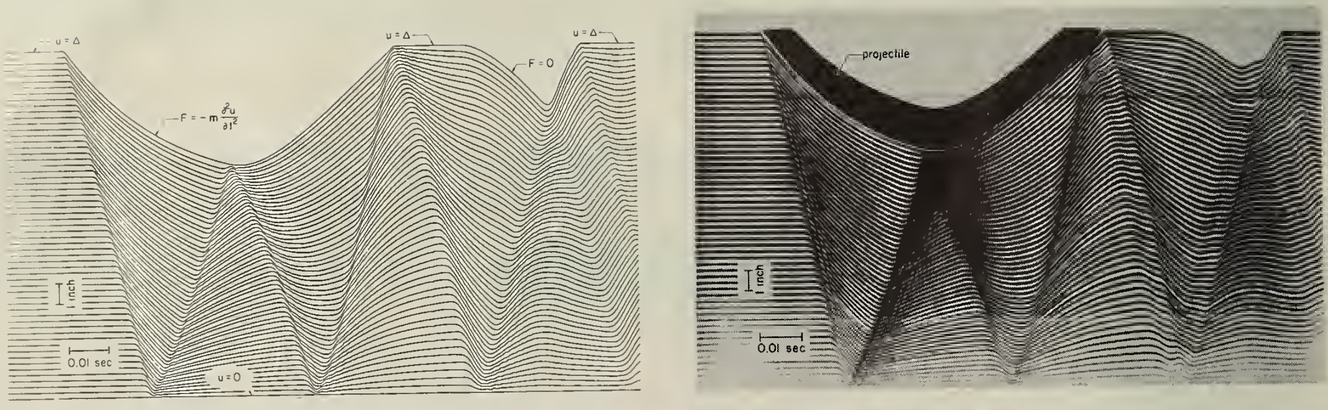
It is hoped that the project will provide information for use by communities considering legislation to reduce the quantity of solid waste generated. On a broader scale, the project should make a major contribution toward wiser use of national resources and help relieve the housewife of that "boxed-in" feeling. ●

THE RESEARCH RECORD

The University of Illinois at Urbana-Champaign has the largest engineering college research program in the nation, according to the 1971 Directory of Engineering College Research and Graduate Study of the American Society for Engineering Education. The $15,019,854 program, administered by the U of I Engineering Experiment Station, provides research experience in 600 projects for 568 graduate students seeking master's degrees and 728 candidates for doctoral degrees.

Of the $15 million, federal government contracts and grants provide $11,397,531; state and local government contracts and grants, $288,884; private, nonprofit organizations and business and industry, $715,562; and other sources, $2,617,877. Leading areas receiving support are: materials research, $3,479,230; physics, $3,071,420; and electrical engineering, $2,280,209.

Engineering related research, which also provides graduate student training but is administered outside the engineering college, includes 56 projects with support of $12,103,429. This includes $10,757,386 for research in the Department of Computer Science in the U of I Graduate College. ●



A theory of spring response to impact developed by professors G. A. Costello and J. W. Phillips of the Department of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign considers the mass of the spring and permits large displacements. The remarkable agreement of this theory with actual experiments is shown by this comparison of the computed response of a spring (left) with an actual photograph of a spring struck by a projectile (right).

SPRING RESEARCH

"If we tacitly assume . . ." has prefaced many a lecture explaining the fundamentals of engineering. The massless spring, the frictionless plane, and the dimensionless cable are all techniques drawn from the engineering professor's bag of tricks as he uses simplifying assumptions to teach beginning students basic concepts of mechanics.

But the real world and the undergraduate classroom are often at odds since springs do have mass, planes have friction, and cables have dimensions. Advanced engineering research calls for techniques far more sophisticated than those appropriate for the undergraduate classroom. In many problems involving springs, not only is the mass of the spring ignored but the compression of the spring is also assumed to be linear. These assumptions allow a simple formulation and solution of the problem, but they do not reflect the actual behavior of a spring as accurately as professors G. A. Costello and J. W. Phillips of the Department of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign would like.

In order to predict more accurately the behavior of compressed springs such as those in an automobile shock absorber, they have developed a theory for spring response to impact which considers the mass of the spring and allows for large displacements. To test their theory, Costello and Phillips compared their calculated response of a spring with the response of an actual spring. The motion of the actual spring was recorded by rapidly moving film which rotated past the spring, showing the motion of the coils as long streaks. The resulting photographs show remarkable agreement between the theory and the actual spring response.

Since springs are used by many different types of machines, this theory will play a major role in a program to develop better design of springs and more durable machines. It has also helped to remove one more "tacit assumption" from the classroom and has brought the study of mechanics one step closer to the real world. ●

HOMEMADE AND HARDWORKING

Radio engineering has come a long way since amateurs first picked up KDKA in Pittsburgh on their handmade crystal rigs. Though the art of picking up radio signals has since extended over interstellar distances, a group of engineers under the direction of electrical engineering and astronomy Professor George W. Swenson, Jr., must share some of the excitement and pleasure of the early amateur. Their handcrafted, 120-foot radio telescope at the Vermilion River Observatory of the University of Illinois at Urbana-Champaign has successfully completed its first research observations.

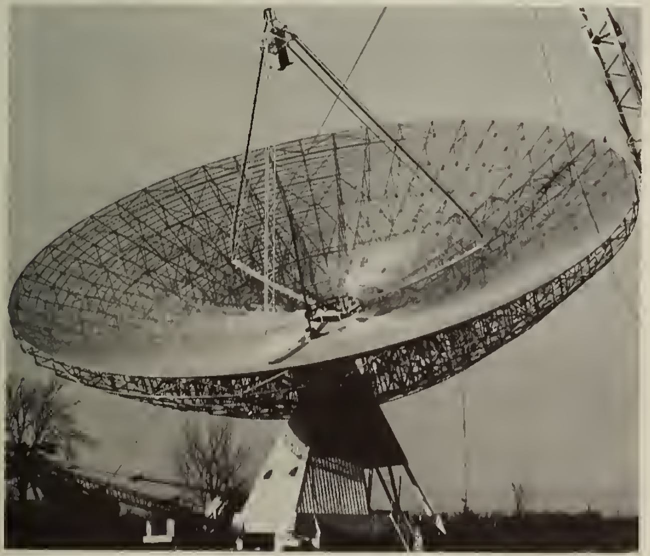
The new radio telescope, located near Danville, Illinois, was constructed, under the supervision of engineers Arno H. Schriefer and Kwang-Shi Yang, by students and academic and nonacademic employees working part-time (*Outlook,* September 1969). Because it was entirely "homemade," the telescope cost much less than one would expect to pay for an instrument of such quality.

The first research observations were carried out in cooperation with two other major telescopes: a 130-foot Cal Tech telescope in the Owens Valley of California and a 150-foot Naval Research Laboratory telescope in Sugar Grove, West Virginia. In addition, six universities and four government agencies cooperated in the project. In order for the instruments to work together accurately, their observations were timed by extremely precise atomic clocks. These clocks, which are accurate to within 3 seconds over 1,000 years, were synchronized by carrying a single clock to each observatory and setting each of the other observatory atomic clocks to it, within a few millionths of a second.

The observations took almost 10 days to complete, with the researchers working 24 hours a day. The data from the three telescopes were recorded on 1,800 reels of magnetic tape. The tape recorded by the Illinois group weighed nearly a ton and contained about 10 times more nonredundant information than all the books in the University of Illinois at Urbana-Champaign Library, which is the fifth largest library in the country. This gigantic mass of data will be processed on National Aeronautics and Space Administration computers which will reduce the information gathered on radio sources in space to a much less bulky result.

By operating two or more telescopes simultaneously in this manner, engineers and scientists can use them as a very-long-baseline interferometer (VLBI). Such an arrangement can measure the diameters of cosmic objects with an accuracy of one ten-thousandth second of arc, roughly the size of a dinner plate on the moon as seen from the earth. The VLBI can measure the position of cosmic objects with the same degree of precision. As a by-product, it determines the distance between telescopes to previously unheard-of accuracy, so that it is potentially able to determine the relative motion of the continents over the surface of the earth.

The success of the new telescope, when combined with its versatility and low cost, seems to prove again the old adage, "If you want something done right, do it yourself." ●



This 120-foot radio telescope at the Vermilion River Observatory of the University of Illinois at Urbana-Champaign has successfully completed its first research observations. The new telescope, located near Danville, Illinois, was entirely "homemade" by students and academic and nonacademic personnel of the University working part-time.

GRANT CONTINUES FISSION STUDIES

What comes out when the nucleus of an atom splits? Nuclear engineers in the University of Illinois at Urbana-Champaign have been working on details of the answer since 1963 and have just received an $82,600 National Science Foundation grant to continue the research another two years.

The project, being carried out under the direction of Professor M. W. Wyman and Professor B. W. Wehring, centers on the fission or splitting of uranium-235, the fuel used in nuclear reactors. Important to the research is the University's research reactor which has a 1.5-million-watt steady operating level and can be pushed for brief intervals to 6,000 million watts. In the complex interactions of nuclear fission, particles and radiation such as x rays are released. Information from the project — answers already found and answers being sought — is important to nuclear engineers and the nuclear industry. ●

CONFERENCE TO CRACK DOWN ON CRACKS

As Goliath remarked to David shortly after their famed encounter, "It's the little things that count." Now, several millenia later, the structural designer often shares Goliath's sentiments. High-strength materials have had increased demands placed upon them through modern applications such as rocket motor casings, aircraft, submarine, and nuclear reactor vessels. Might does not always make right, however; as these materials have been adapted to meet their demands, they have become more and more susceptible to spectacular and possibly catastrophic failure resulting from a seemingly insignificant crack or flaw. And, like Goliath, their fall is mighty.

Unlike Goliath, however, the modern designer has something extra going for him. As the possibility of failure becomes more likely with the advent of new high-strength materials, the study of their failure mechanisms, with an eye toward prediction and prevention, has increased also. The relatively new area of fracture mechanics specializes in the study of these materials and how they fail. Loosely defined, fracture mechanics is an engineering tool that lets the designer learn to live with mistakes. In the casting, forging, and fabrication of new high-strength materials, small flaws and cracks are inevitable. They can lead to failures as annoying as a broken toaster or as spectacular as a shattered 260-inch rocket casing. Fracture mechanics attempts to predict the behavior of these imperfections, identifying those which are harmless, keeping an eye on those which may become hazardous, and predicting the material's life before failure.

Since fracture mechanics is still in its infancy, specialists are always eager to exchange information and share the results of their studies with those who can use or apply them. For this reason, the Department of Theoretical and Applied Mechanics of the University of Illinois at Urbana-Champaign is sponsoring the Fifth National Symposium on Fracture Mechanics. It will be held August 31 through September 2, 1971, at the Urbana-Champaign campus. Specialists from several areas of advanced fracture mechanics will present theoretical and experimental papers on their studies ranging from fundamental investigations of crack propagation to testing and analysis of high-strength materials.

The engineer or scientist who feels he may be heading for a crack-up with materials and wishes to sit in on state-of-the-art presentations of the newest advances in fracture mechanics should contact Professor H. T. Corten, 312c Talbot Laboratory, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

Arthur B. Chilton, Professor of Civil Engineering and of Nuclear Engineering at the University of Illinois at Urbana-Champaign, has been elevated to Fellow of the American Nuclear Society, an honor reserved for acknowledged attainment in the nuclear field by notable original research or invention, by technical leadership of substantial scope, or by outstanding leadership as a teacher. Professor Chilton has been honored for his outstanding research and teaching in the areas of radiation transport, shielding, and dosimetry. He is presently serving the American Nuclear Society as a member of the Executive Committee of Shielding and Dosimetry Division and as a member of the subcommittee ANS-6 of the Standards Committee.

Donald U. Deere, Professor of Civil Engineering and of Geology at the University of Illinois at Urbana-Champaign, has been elected to the National Academy of Sciences. Professor Deere's research interests center on the application of engineering geology and rock mechanics to the design and construction of tunnels and other large underground cavities and to the stabilization of landslides. His election to the National Academy of Sciences brings to twenty-two the total number of University faculty so honored as foremost scientists in their fields.

Professor **James W. Bayne,** Associate Head of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign, has been elected vice-president of the Association of College Honor Societies. He has been a member of the association's council and chairman of its committee on constitution and bylaws. For more than a decade he served as national secretary-treasurer of Pi Tau Sigma, mechanical engineering honor society. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 13, NO. 1, SEPTEMBER 1971

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AT URBANA-CHAMPAIGN

inside outlook:

AIRPORT PAVEMENT SHORT COURSE
CALIFORNIA EARTHQUAKE STUDIES
AIR POLLUTION COMPUTER GAME
SEWERAGE FLOW MONITORING DEVICE

PLANE GROUNDWORK

Airport managers, now members of the jumbo jet set, are running into a series of problems related to modern aircraft. One of the more serious of these problems is obsolete runway pavements. As a result, airport pavement engineers are questioning the validity of design procedures based on outdated aircraft. With an eye to present financial restrictions, the pavement engineers are also seeking ways to design tomorrow's runways on today's budgets.

A short course, to be held November 9–11 at the University of Illinois at Urbana-Champaign, will examine the problems of airport pavement design from the viewpoint of the practicing engineer. Speakers from both academic and practicing professions will discuss the blending of fundamentals with applied technology to produce reliable and workable design procedures. All critical variables, including economics, will be combined in a system design approach to airport pavement. Each course attendee will have an opportunity to participate in the design of a real pavement system.

The course will be sponsored by the Department of Civil Engineering at the University of Illinois, the Airport Operators' Council International, and the Construction Engineering Research Laboratory of the U.S. Army Corps of Engineers. Additional information may be obtained by contacting Professor E. J. Barenberg, Department of Civil Engineering, 111 Talbot Laboratory, the University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. Telephone 217–333–6252. ●

PLAY IT AGAIN, SAM

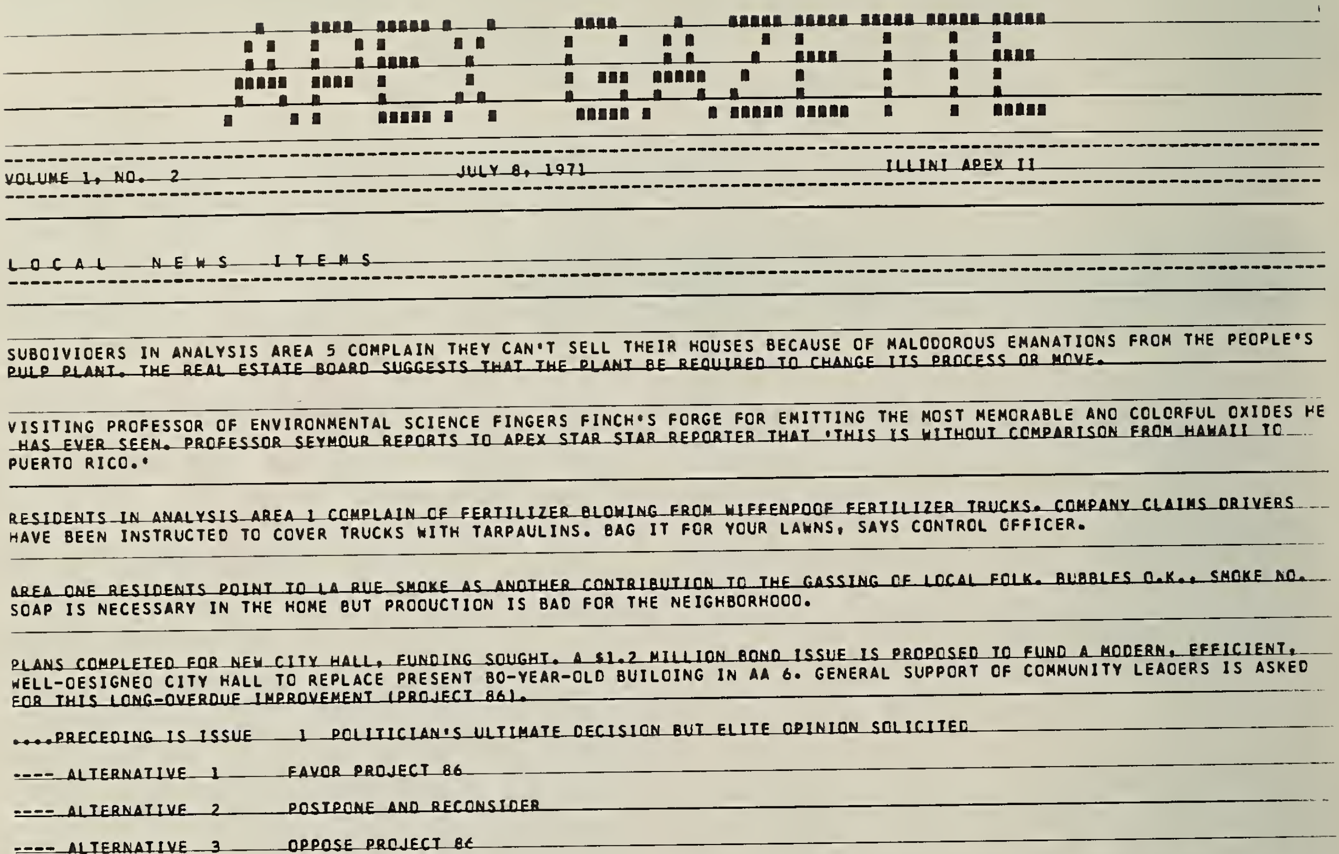
Not "As Time Goes By," but the February 9 earthquake which killed sixty-five persons and caused more than $500-million damage in the San Fernando Valley of California will soon be replayed in a laboratory of the University of Illinois at Urbana-Champaign.

Mathematical analyses of the quake and its effect on structures are now being made by U of I engineers under a $122,300 National Science Foundation research grant. Results of the analyses will be tested with scale model structures on the University's earthquake machine, which can be programmed electronically to duplicate the damaging tremors of the actual event. On the machine, structures are scaled at one inch to a foot, a reduction of one-twelfth; and to compensate for the loss of mass in scaling the buildings down, the shocks are made twelve times faster and twelve times harder than the actual earthquake.

The research is under Professor Nathan M. Newmark, Head of the Department of Civil Engineering, and civil engineering professors Mete Sozen and D. A. W. Pecknold. Professor Hiroyuki Aoyama of the University of Tokyo will come to Illinois to take part in the project. University of Illinois engineers have made similar studies of other major quakes around the world, preliminary to mathematical and laboratory research. ●

TO BE CONTINUED

Construction and research on the superconducting linear accelerator at the University of Illinois at Urbana-Champaign, to be completed by the end of 1971, will be continued under a $335,000 National Science Foundation grant. This fourth grant brings to more than $1.3 million the total received from the foundation for the project. Project directors are Professor James S. Allen, Professor Peter Axel, and Professor Alfred O. Hanson, all of the Department of Physics. ●



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VOLUME 1, NO.  2                    JULY 8, 1971                    ILLINI APEX II

L O C A L   N E W S   I T E M S

SUBDIVIDERS IN ANALYSIS AREA 5 COMPLAIN THEY CAN'T SELL THEIR HOUSES BECAUSE OF MALODOROUS EMANATIONS FROM THE PEOPLE'S
PULP PLANT. THE REAL ESTATE BOARD SUGGESTS THAT THE PLANT BE REQUIRED TO CHANGE ITS PROCESS OR MOVE.

VISITING PROFESSOR OF ENVIRONMENTAL SCIENCE FINGERS FINCH'S FORGE FOR EMITTING THE MOST MEMORABLE AND COLORFUL OXIDES HE
HAS EVER SEEN. PROFESSOR SEYMOUR REPORTS TO APEX STAR STAR REPORTER THAT 'THIS IS WITHOUT COMPARISON FROM HAWAII TO
PUERTO RICO.'

RESIDENTS IN ANALYSIS AREA 1 COMPLAIN OF FERTILIZER BLOWING FROM WIFFENPOOF FERTILIZER TRUCKS. COMPANY CLAIMS DRIVERS
HAVE BEEN INSTRUCTED TO COVER TRUCKS WITH TARPAULINS. BAG IT FOR YOUR LAWNS, SAYS CONTROL OFFICER.

AREA ONE RESIDENTS POINT TO LA RUE SMOKE AS ANOTHER CONTRIBUTION TO THE GASSING OF LOCAL FOLK. BUBBLES O.K., SMOKE NO.
SOAP IS NECESSARY IN THE HOME BUT PRODUCTION IS BAD FOR THE NEIGHBORHOOD.

PLANS COMPLETED FOR NEW CITY HALL, FUNDING SOUGHT. A $1.2 MILLION BOND ISSUE IS PROPOSED TO FUND A MODERN, EFFICIENT,
WELL-DESIGNED CITY HALL TO REPLACE PRESENT 80-YEAR-OLD BUILDING IN AA 6. GENERAL SUPPORT OF COMMUNITY LEADERS IS ASKED
FOR THIS LONG-OVERDUE IMPROVEMENT (PROJECT 86).

....PRECEDING IS ISSUE    1  POLITICIAN'S ULTIMATE DECISION BUT ELITE OPINION SOLICITED

---- ALTERNATIVE  1       FAVOR PROJECT 86

---- ALTERNATIVE  2       POSTPONE AND RECONSIDER

---- ALTERNATIVE  3       OPPOSE PROJECT 86
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The *APEX Gazette*, a computer print-out "newspaper," is distributed to the players of APEX, a computer game which simulates the decision-making process needed to solve air pollution problems in large metropolitan areas. APEX, played twice at the University of Illinois at Urbana-Champaign, gives participants the opportunity to assume active roles in the management of a simulated city of 250,000. A computer contains basic data about this typical city; and game players make decisions about major issues, providing the computer with input which keeps the game going. The *Gazette* informs the players of the current issues.

THE PLAY'S THE THING

A distraught ex-councilman ponders the election he just lost. What did the voters really want — a new airport, or more funding for the Air Pollution Control Office? The plant manager of Finch's Forge looks at the firm's cost figures from the previous year. How can he install air pollution abatement equipment demanded by the Air Pollution Control Office when profits have been falling off steadily? An elated land developer discovers that Boxey Container Corporation is planning to locate in an area where he owns twelve acres. Now he only has to interest the plant officials in his land and convince the Air Pollution Control Office that Boxey is not a polluter.

This is a day in the life of APEX, U.S.A., typical city with a population of 250,000. And the leading citizens of APEX are constantly making decisions which affect their futures and the future of the community. The difference between APEX and other cities is that APEX's citizens are getting a chance to learn by their mistakes. APEX is a proving ground where students at the University of Illinois at Urbana-Champaign, decision-makers of the future, are getting a chance to "live" and "work" in a real city, accepting and acting upon the consequences of their every decision.

Strictly defined, APEX (Air Pollution Control Exercise) is a computer game: a simulation of the decision-making processes needed to solve air pollution problems which could occur in a large metropolitan area. The players, who assume the roles of city and county politicians, legal advisers, leaders of industrial concerns, land developers, urban planners, and pollution control officers, are the decision-makers who make the game work. Developed at the University of Southern California at Los Angeles, APEX has been played twice at the U of I, with participants ranging from engineering, law, urban planning, architecture, journalism, and biology students, to federal Environmental Protection Agency (EPA) trainees. Directors of the APEX project at the U of I are James Stukel, Professor of Civil Engineering and of Mechanical and Industrial Engineering, and Sheldon Plager, Professor of Law. The project was sponsored by the EPA in conjunction with the U of I Colleges of Engineering and Law. APEX was taught as a seminar during the spring semester, 1970–71, and as a three-day session during which four years of decisions and data were compressed and analyzed by some forty players.

But APEX is more than just a course or a learning session. It is an air-conditioned room where temperatures rise above 100 degrees when irate industrialists confront air pollution control officials who are determined to enforce laws. It is a group of nervous county commissioners trying to balance budgets on one hand and constituents on the other. And it is a voting public, relentless in its desires to have better roads, cleaner air, more parks, and improved services, all with lower taxes.

How does APEX work? The computer contains a basic set of data about population, employment, land use, public facilities, air characteristics, and activities of industries, land developers, and political jurisdictions. The data are completely realistic, taken from a middle-sized Michigan city. Periodic computer print-outs show dynamic relationships involved in the growth and distribution of population and employment, the sale of real estate, the response of voters to bond issues and to candidates seeking election, and the changing air quality. Included in the computer print-out is the *APEX Gazette*, a newspaper, distributed to all players, which gives the national, state, and local news of the day.

APEX players are assigned roles which are usually quite different from those which they are training for. For example, EPA trainees can be real estate developers or industrialists. The environment, in the form of the computer print-outs, provides opportunities, problems, and issues with which the players must deal. Role players must make decisions on such matters as annual budgets, tax rates, production rates, plant expansion, the purchase and sale of land, and capital improvement projects. Also, each player votes on major political issues, detailed in the *APEX Gazette;* and his voting record, along with all of his other decisions, are fed into the computer to provide the dynamics for the next day's print-out. The print-out tells it like it is, showing the player where he went wrong. It is then up to him to figure out "how" he went wrong.

APEX is not a game of chance, and the only prize is the player's experience in making decisions in a real life situation. Textbooks can tell a student about pollution control, urban planning, government, or business administration; but APEX makes him a pollution control officer, or an urban planner, or a county commissioner, or an industrialist. He begins living the life he learned about in the classroom; and he often realizes that what works on paper does not work in reality, especially when industrialists, land developers, air pollution control officers, taxpayers, and city and county officials are all looking out for their own interests. ●

DO I HEAR FIVE?

A team of astronomers and chemists from the University of Illinois at Urbana-Champaign has discovered the first molecule in space to contain four chemical elements. The discovery was in a region of the Milky Way where radio astronomers have found most of the twelve other molecules — all containing three or fewer chemical elements — which have been discovered in space in the last three years.

The five-member team, supported by funds from the National Science Foundation, included Professor George W. Swenson, Jr., and research associate Robert H. Rubin, both astronomers; and Professor Richard C. Benson, Professor W. H. Flygare, and graduate student Howard L. Tigelaar, all chemists. The discovery was made with the 140-foot radio telescope of the National Radio Astronomy Observatory, supported by NSF, at Green Bank, West Virginia. ●

THE EFFLUENT SOCIETY

As a society increases its affluence, it also increases its effluents. The liquid residue of our modern urban society is increasing at a staggering rate and has become a serious problem in many cities. The sewer systems in most urban areas were built years ago, without anticipation of the present population growth. These systems, which were fine for their time, usually combined storm and sanitary sewers. But with the increased demand for handling of huge amounts of liquid wastes, a surge — such as heavy rain — severely overloads the sewers and leads, all too frequently, to an overflow of raw sewerage.

One solution to this problem, separation of sanitary and storm sewers, is a lengthy and expensive procedure. Another solution, dumping the overflow into nearby lakes or rivers, is meeting increasingly stiff resistance from state environmental agencies. However, research at the Water Resources Center of the University of Illinois at Urbana-Champaign indicates a third solution which would satisfy both the budget-conscious city fathers and the conservation-minded state officials. A project, under the direction of civil engineering Professor Harry G. Wenzel, may offer the cities a way of making full use of their combined sewer systems, thus eliminating costly new construction and destructive overflows.

In most combined systems, sections of the system carry a high load while other sections are loafing along at half capacity. If the flow could be directed so that all portions of the system carried a nearly equal load, the effective capacity of the system could be increased. But before the flow can be diverted, there must be some means of knowing which parts of the system are overloaded and which are not working at capacity. Professor Wenzel's research will develop a device for continuous monitoring of flows in sewers which will report the state of the system to a central data collection point. There, like a policeman directing heavy traffic, workers could efficiently route the flow to make the best use of the system.

The heart of the monitoring system, the measuring device, must provide an accurate measure of the discharge while creating the least disturbance to the flow of the system. The monitor will create a geometric constriction in the sewer pipe. By measuring the depth of flow both just before and within the constriction, the amount of the discharge can be determined. Professor Wenzel's technique will be useful in either full or part-full sewers. To date, most other devices for measuring flow have only been useful in part-full sewers, and their design has made installation possible only at the discharge outlet of the sewer, making it difficult to know what the flow was within the system itself.

As with any new idea, there are a great many details to be worked out in Professor Wenzel's project. Additional studies will explore the exact effect of placing the device in the sewer. Since sewers with different loads may react differently, exact calibration curves for determining the amount of discharge must be tabulated. Initially, the project will devote itself to these very practical problems. It will take approximately two years to complete the development and construct a prototype model for actual testing. In the meantime, city engineers will hold their breath, and if effluents continue to increase at the present rate, perhaps their noses as well. ●

PEOPLE AND PLACES

Professor **Edwin H. Gaylord** of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign has been presented with the Western Electric Fund Award of the American Society of Engineering Education. Professor Gaylord was honored for his distinguished career in engineering education and his contribution to the engineering profession.

The National Academy of Sciences has named Dean **Daniel C. Drucker** of the College of Engineering at the University of Illinois at Urbana-Champaign to its committee charged with a broad eighteen-month study of ways that materials sciences and engineering can contribute to the national well-being. The committee will give attention to problems of recycling and waste disposal to conserve nonrenewable resources and environmental quality. This interdisciplinary field was selected for study because of its successful linking of science and engineering for useful applications. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 13, NO. 2, OCTOBER 1971

inside outlook:

FRACTURE CONTROL PROGRAM
CE CENTENNIAL CELEBRATION
A SLEEP LEARNING MACHINE
MODELS OF THE GREAT LAKES BASIN
CONTINUING PLATO DEVELOPMENT

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AT URBANA-CHAMPAIGN

BUT WHY DID IT BREAK?

It's Saturday afternoon, and you discover that some bolts on your lawn mower have become loose. You begin to tighten them, and suddenly the bolt head snaps off. An annoying problem, but one that can be solved with a few angry words and a trip to a hardware store where you purchase some new twenty-five cent bolts. During the refining of gasoline, a large pressure vessel for catalytic cracking of crude oil suddenly ruptures. Estimated damage to the vessel: over $12 million. A refinery is closed down until repairs can be made, and other damaged equipment can be replaced. Failure of the bolts and the reactor vessel are both problems of metal fracture; but while the bolt manufacturer merely makes another sale, the vessel manufacturer is faced with a very angry customer and a very expensive problem.

A new applied research Program of Fracture Control now being instituted in the College of Engineering at the University of Illinois at Urbana-Champaign could provide information to both manufacturers that would help them find out why each product failed. The program is concerned with the safety and reliability of mechanical equipment, and its major aim is the acquisition of knowledge that can be used by industry to reduce the incidence of failure of mechanical components in service. The program, of special interest to manufacturers of automobiles, trucks, agricultural and earthmoving machinery, industrial equipment, and other heavy machinery, will seek to provide important information for practical use in component design and development. It is a cooperative venture between participating industries and the College of Engineering, and the eventual size and scope of the program will depend upon the amount of cost sharing acceptable to the manufacturers sponsoring the research. College of Engineering staff and graduate students will provide creative impetus to the program. Pertinent research discoveries, which will concern mutual problems of industry, will be distributed to participating firms through technical reports and direct contacts.

The program has been set up to cross departmental boundaries, making full use of specialists in all areas related to fracture, whether due to static, dynamic, or environmental conditions of operation. R. W. Bohl, Professor of Nuclear Engineering and of Metallurgical Engineering; T. J. Dolan, Professor of Theoretical and Applied Mechanics; J. Morrow, Professor of Theoretical and Applied Mechanics; and W. H. Munse, Professor of Civil Engineering, are serving as a Steering Committee in the development of the program. Ten other members of the professorial staff are serving on "Task Groups" which will present specific proposals for research. Comments and suggestions from participating industries will be welcomed, but the program is not intended to explore problems unique to a specific company. Rather, the efforts will be devoted to longer-term comprehensive studies of mutual problems of industry, providing technical reports directly applicable to the industrial development of mechanical equipment. In the past, engineers in industry often have had to obtain obsolete information by wading through stacks of technical journals.

In its initial stages, the program will be directed toward research on fracture control of commercial steels and irons widely used in the automotive, earthmoving, and agricultural implement fields. Some of the effort may also be concerned with nonferrous metals, particularly those of importance in aircraft structure and propulsion systems. Early emphasis will be centered in four areas: welded components of high-strength, low-alloy steels; fatigue and cumulative damage; cast metals; and corrosion and stress-corrosion problems.

The Program on Fracture Control will put the latest technological information at the fingertips of participating firms, thus offering their engineers an opportunity to save development costs and to improve the safety and reliability of their products. In other words, it will give them some insight into why things break, and how to avoid catastrophic failure of products in service. ●

100 YEARS OLD AND GROWING

Congratulations are in order for the Department of Civil Engineering at the University of Illinois at Urbana-Champaign, which will be 100 years old next spring. The department granted its first degrees, four of them, in the spring of 1872. Since that time, the department has granted 5,838 Bachelor of Science degrees alone. In the 1970–71 academic year, 123 Bachelor of Science, 106 Master of Science, and 32 Doctor of Philosophy degrees were awarded by the department.

A Centennial Celebration, consisting of events scheduled for the fall of 1971 and the spring of 1972, is planned by the department. To kick off the celebration, the Civil Engineering Alumni Lecture Series is presenting a speech by John E. Corbally, Jr., new President of the University of Illinois. President Corbally, former Chancellor and President of Syracuse University, assumed his new duties on September 1, 1971. The speech, to be preceded by a dinner, will be held on October 29 at 8:30 p.m. in the Illini Union on the Urbana campus. ●

TO SLEEP, PERCHANCE TO LEARN

For most college and university students sleep and study don't mix — one is usually sacrificed for the other, and the problem has come to be accepted as a condition of higher education. However, a group of students at the University of Illinois at Urbana-Champaign think they have found a way to have the best of both worlds, and they are anxiously awaiting the results of experiments to see if their solution works.

The U of I students, all participants in a freshman-level general engineering course, GE 104, have chosen to study the efficient usage of the time spent sleeping as one of their design projects. Project adviser is Professor L. Daniel Metz of the Department of General Engineering. The students have researched the possibilities of so-called sleep learning and have come up with the design of a machine which will hopefully allow a person to learn while he is deriving the physiological and psychological benefits of sleep.

The first step toward design of the machine was a thorough study of sleeping patterns done in conjunction with Rosalind Cartwright, Director of the Sleep and Dream Laboratory of the University of Illinois at Chicago Circle. It was determined that one sleeps in a pattern which consists of periods of deep sleep followed by periods of lighter sleep or dream sequences. When a person is approaching a period of lighter, dream sleep, he can be aroused to a state of semiconsciousness and be open to "sleep learning." The best type of subject to study while asleep is one which requires rote learning, like a language. The machine designed by the U of I student research team can be set to "interrupt" a person's dream sleep, awakening him to a point where he can begin learning.

Operation of the machine is really quite simple. Once a student's sleep pattern is established, a timer is set which will awaken him gently right before he reaches the dream level. Awakening is done by a constant frequency tone of increasing loudness. When the student becomes aware of the tone, he pushes a button which stops the tone and activates a tape recorder. After five minutes, the recorder asks the student if he is still awake. If he is, he pushes the button and continues the lesson for another five minutes. If he does not respond, the tone awakens him again. The lesson proceeds in this manner for as long as the student wishes to "sleep learn."

Construction of a prototype machine is scheduled to begin shortly and will be financed through a grant from the Bodine Fund, a fund set up to finance undergraduate research in the College of Engineering at Urbana-Champaign. Testing by Professor Cartwright will begin as soon as construction is completed. If all goes well, students may soon be able to enjoy the simultaneous benefits of sleep and learning, although some of them may object to having their dreams interrupted. ●

Illuminated by a fine line of light, this apparatus is being used for a Raman scattering experiment in the Materials Research Laboratory of the University of Illinois at Urbana-Champaign. This fine line is the beam from an argon ion laser which lights up a crystal inside a cryastat. A small amount of scattered light is emitted at frequencies different from those of the laser beam. The spectrum of the light emitted by the crystal is analyzed by a spectrometer. This technique, Raman scattering, yields important information concerning the nature of the crystal.

FROM GREAT TO GREATER LAKES

If our forefathers had had a crystal ball and could have looked into the future of the Great Lakes, those involved with development of the lakes and the land area around them would undoubtedly have done things very differently. But no such crystal ball existed, and the Great Lakes basin grew into one of the most prosperous industrial areas of the world. And along with the prosperity came pollution, overcrowding, and frequent abuse of the land and waterways.

There still does not exist a complete set of data for use in projecting the future development of the Great Lakes basin, but work being done in the Hydrosystems Laboratory of the University of Illinois at Urbana-Champaign should produce such data within the next two years. Professor D. D. Meredith of the Department of Civil Engineering and D. M. A. Jones, Associate Meteorologist with the Illinois State Water Survey, are now completing the first phase of a project to develop mathematical models which could be used in the evaluation of the effects of precipitation, evaporation, and surface runoff on the lake levels. This would in turn provide planners with input data to develop water quality models and also data for use in projecting changes that different land uses around the lakes would cause. If planners know the existing state of the lakes during certain conditions, they will have a base with which to compare changes in patterns. For example, increased urbanization or the construction of a nuclear power plant will increase runoff in certain areas, thus affecting such things as shoreline damage and navigation.

The first phase of the Great Lakes study, sponsored by the federal Office of Water Resources, concerns computation of the monthly precipitation on the lakes themselves, the evaporation from the lake surfaces, and the surface runoff into the lakes. Data from the years 1946 through 1965 have been obtained from the U.S. Weather Bureau, the U.S. Geological Survey, and their Canadian counterparts. Monthly runoff and precipitation maps for the basin have been drawn, and equations for future predictions are being developed from the maps. The second phase of the project will begin shortly with the development of models to evaluate the effects of the individual components on lake levels. Previous information was expressed only in net terms.

The seemingly tedious task of preparing some 500 maps of the Great Lakes basin should someday make it a lot easier for planners, such as the Great Lakes Basin Commission, to develop mathematical models with which to evaluate alternative basin development proposals. And hopefully, with the proper data and wise planning, the Great Lakes will become even greater. ●

Professor D. D. Meredith of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign is shown drawing one of some 500 Great Lakes basin maps which have been prepared to show precipitation on the lakes, evaporation from the lakes, and runoff into the lakes from the years 1946 through 1965. Data from the maps will be used in the University's Hydrosystems Laboratory to develop mathematical models which could be used to plan future basin development.

PLATO GRADUATES

Economical, large-scale, computer-aided instruction from kindergarten through college has moved a step closer to reality with preparations made at the University of Illinois at Urbana-Champaign for production of 10 consoles for the PLATO (Programmed Logic for Automatic Teaching Operations) computer-based education system (*Outlook,* January 1969), with tentative plans for production of 250 more consoles.

Production is a major step toward taking the PLATO system out of the U of I where it was invented and into schools, with low-cost telephone lines connecting as many as 4,000 consoles to a central computer. The PLATO system has been developed over the past five years under Professor Donald L. Bitzer, Director of the Computer-based Education Research Laboratory.

The consoles will include two devices invented at the University. Each console will have an eight-inch square plasma display panel on which words, sentences, mathematics, or diagrams appear under computer control. Though the panel appears much like a television screen, its electronic operation is quite different. The other device enables the computer to select any one of 256 color images on a small slide placed in the console and to project it on the panel along with any other information the panel is presenting. The consoles also will have connections for a third U of I invention, a sound device — again under computer control — which can select and play any one of more than 2,000 messages, such as foreign words or sentences, music, or other audible material.

When production is complete, the first 10 consoles will be tested in use on the campus, and the next 250 on the campus and nearby as another step toward getting 4,000 into use by the end of 1974. Each console will have a display panel and an electric keyboard used by the student to communicate with the computer, requesting lessons and information, answering problems, checking answers, and getting special help when needed. Each student progresses at his own speed, and the computer can provide a large number of instructional programs at the same time. Teachers, freed from routine instruction, can give personal attention and help to students.

During the past five years, more than 150,000 hours of instruction have been given by PLATO in courses from preschool to college graduate work, and when the consoles are complete, PLATO will graduate from the U of I as a full-fledged teacher with many classroom hours ahead. ●

PEOPLE AND PLACES

Professor **Moreland Herrin** of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign was one of two directors elected at the annual meeting of the Association of Paving Technologists. He was named director-at-large of the international organization of specialists in the field of asphalt paving.

The American Society for Testing and Materials has honored **Thomas J. Dolan,** Professor of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign, with its Award of Merit. Professor Dolan also has been named a Fellow of the society. He was cited for "his long and distinguished service to the society and the profession, for his ability to inspire others to contribute to the study of material fatigue, and for his contributions to standardization in this area."

The American Society of Agricultural Engineers has awarded blue ribbons for outstanding effort and achievement in the development of noteworthy educational aids to three members of the faculty in the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign. Professor **D. L. Day** was honored for his publication entitled "Aerobic Treatment of Livestock Wastes." Another publication blue ribbon went to Professor **A. J. Muehling** for "Swine Housing and Waste Management." In the category of slides and filmstrips, Professor **R. F. Espenschied** was honored for a presentation entitled "Asphalt Roofing Transparencies," and for a series of ten slide sets on testing diesel injection pumps and servicing diesel engines. ●

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COLLEGE OF ENGINEERING
VOL. 13, NO. 3, NOVEMBER 1971

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AT URBANA-CHAMPAIGN

inside outlook:

PROTECTIVE COOLING GARMENT DEVELOPED
CIRCLE CONCRETE CONFERENCE
PROBLEM SOLVING WITH SUPERCOMPUTERS
HEAT TRANSFER RESEARCH
FOURTEENTH WATER QUALITY CONFERENCE

KEEP A COOL HEAD

Man is a curious animal, determined to explore new frontiers, including outer space. It is up to engineering to take him where he wants to go, and in comfort, no less. Making man more comfortable in thermally hostile environments is the aim of research now under way in the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign. Originally concerned only with extravehicular space suits, the research, sponsored by the National Aeronautics and Space Administration, has taken on added dimensions and is now looking at ways of protecting man as he engages in down-to-earth occupations. Miners, deep sea divers, helicopter pilots, race car drivers, and steel mill workers may all some day benefit from work now being done at the U of I.

The researchers, J. C. Chato, Professor of Mechanical Engineering; B. A. Hertig, Associate Professor of Mechanical Engineering and of Physiology; and A. Shitzer, Visiting Assistant Professor of Mechanical Engineering, are attempting to learn about human reactions to hostile environments and to develop new ways for making man more comfortable where he would normally be uncomfortable. Possibilities of the research range from finding ways to keep trapped miners alive until they can be rescued to helping helicopter pilots stay cool and collected while in flight.

Mathematical models of the thermal behavior of living biological tissue have been developed to project temperatures, heat fluxes, and time needed for body temperatures to reach a state of equilibrium. Blood flow effects have been included in the models because heat transfer is an important concomitant of blood circulation. Particular applications of the models have been directed toward the problem of extending the thermophysical capabilities of man.

A cooling garment, including a cooling hood, has been constructed to provide a "micro-climate" for man by means of cooling tubes that are in direct contact with the skin. The garment consists of individual pads which provide an independent supply of cooling water to six separate regions of the body. Human experiments with the garment, and with individual cooling pads attached to various parts of the body, have been directed at exploring the characteristics of independent control of temperature and removal of excess heat from separate regions of the body. Activity schedules, consisting of alternate sessions of standing and treadmill walking, have been conducted with test subjects in the Laboratory for Ergonomics Research.

Results of the experiments to date have been very enlightening to the researchers. It was found that different parts of the body can be cooled at different temperatures. For example, working muscles can be kept at a cooler temperature than idle muscles. In addition, it was discovered that the head requires more cooling than the rest of the body and that a person can remain relatively comfortable in extreme heat if his head and neck are kept cool. Head and neck cooling devices could have direct applications in hot but tolerable environments, such as steel mills, and in areas of limited space, such as helicopter cockpits. However, it is not yet known why head and neck cooling keeps a person comfortable. It has been found that changes in arterial temperature in the head and neck are probably not responsible for the cooling effects. Studies of cold perceptors in the head and neck will have to be made to determine what effect they have on a person's total comfort. But more physiological data on local metabolic and blood flow rates are needed to improve the models so that the right answers can be found.

In the future, the U of I team plans to investigate more ways of keeping man comfortable while he works in thermally hostile environments. Questions of how much protection is needed and how long certain types of protection can be tolerated by the human body remain to be answered. To do this, the researchers feel they must get a better handle on mathematical modeling of the complete human body. They now have developed a model that depicts the body as a distributed rather than a lumped system. Previously the body was viewed as a group of segments, each with its individual temperature. The present model predicts the behavior of the whole system in a changing environment.

With improved models and more physiological data, the researchers should be well on their way to increasing man's comfort in a myriad of occupations. And in the process, they may turn some hot heads into cool heads. ●

CIRCLE CONFERENCE TO CONQUER CONCRETE

A conference, "New Materials in Concrete Construction," cosponsored by the Departments of Theoretical and Applied Mechanics and Civil Engineering at the University of Illinois at Urbana-Champaign and the Department of Materials Engineering at the University of Illinois at Chicago Circle, will be held December 15, 16, and 17 on the Circle campus.

The purpose of the conference is to acquaint builders, engineers, and architects with use of new materials in concrete construction and with possible future applications of new materials. Lectures and laboratory demonstrations by leading universities and industry experts on state-of-the-art polymer concrete, expansive cement, artificial aggregates, ferro-cement, fiber reinforced concrete, and regulated set cements are planned. For additional information, contact S. P. Shah, Associate Professor of Civil Engineering, the Department of Materials Engineering, College of Engineering, the University of Illinois at Chicago Circle, Chicago, Illinois 60680. ●

WHAT CAN A DINOSAUR DO FOR YOU?

Fourth-generation supercomputers like ILLIAC IV, developed at the University of Illinois at Urbana-Champaign (*Outlook,* April 1966), are the wonders of our age. But just how efficient are these monsters of technology? And in what areas can they be used most effectively? The answers to these questions and others were explored in detail at the Workshop on Computational Fluid Dynamics, held last summer at the U of I.

The workshop, sponsored by the Office of Naval Research, the ILLIAC IV project, and the Coordinated Science Laboratory, brought together a group of some forty scientists interested in discussing the solutions to fluid dynamics problems using fourth-generation supercomputers. This was the first time people interested in fluid dynamics assembled to talk specifically about the compatibility of supercomputers with methods of solving their problems. In the past, only the methods themselves were explored.

Supercomputers have special limitations, just as they have special applications. S. M. Yen, Professor of Aeronautical and Astronautical Engineering and of the Coordinated Science Laboratory, and his associates have been planning to use large computers to tackle unsolved multidimensional gas dynamics problems. Why are supercomputers specially suited to these problems? Quite simply because they reduce man hours to computer seconds, eliminating lifetimes of human calculation. However, many conventional computer methods used to solve fluid dynamics problems do not utilize the full capabilities of the supercomputers. Therefore, it is not economically feasible to put a supercomputer through a task which will leave it partially idle.

The current effort of Professor Yen and his associates is devoted to the efficient utilization of ILLIAC IV to solve rarefied gas dynamics and continuum fluid dynamics problems. Rarefied gas dynamics deals with nonequilibrium gas flow problems which require microscopic treatment according to kinetic theory to determine gas flow properties. A Monte Carlo method (*Outlook,* January 1968) to simulate the intermolecular collision process in a number of rarefied gas flow problems has been developed and used by the gas dynamics group to solve the Boltzmann equation, the basic equation in kinetic theory. With this method, the group is able to reduce the computation time of billions of collisions between molecules, required to solve a problem, from months to an hour.

Success in solving these problems has led to plans for tackling more complex problems using ILLIAC IV. Since ILLIAC IV not only permits the computation of sixty-four collisions at the same time due to its parallel nature, but also is a much faster machine than the computer now being used, computations can be made about 1,500 times faster. The group is now undertaking the task of revising the Monte Carlo method so that it could be applied to a wide range of complex problems that occur in aerodynamics, electronics, aeronomy, and environmental controls. Professor Yen has received a grant from the Environmental Research Laboratories of the National Oceanic and Atmospheric Administration to study an aeronomy problem which concerns the interaction between electrons and neutral molecules.

Even though continuum fluid dynamics problems are quite simple in that only macroscopic treatment is necessary, accurate simulation of the physical processes in the fluid flows for large-scale problems requires faster and larger fourth-generation supercomputers. However, careful consideration of the constraints imposed by the supercomputers is needed to find ways of implementing methods of also solving continuum fluid dynamics problems on these computers. Professor Yen and his associates are studying the ways of implementing existing numerical methods of solving the basic equations for fluid dynamics problems on ILLIAC IV and the possibility of developing new methods specially adapted to this computer.

It was the aim of the workshop to find out what kinds of problems need to be solved with fourth-generation computers and to discuss the exploitation of these computers for fluid dynamics research. Hopefully, with increased understanding of the possibilities for supercomputers, they will look less like monsters and more like friends to the people in the field of fluid dynamics. ●

THERE'S NOTHING FISHY HERE

When a group of chemical engineers at the University of Illinois at Urbana-Champaign study fins in boiling liquids, they are not, as you might think, helping Mrs. Paul find a new method of fish preparation. Instead, they are studying the rate of heat transfer from metal fins to boiling liquids. The fins are not part of a fish but are the protrusions on large metal surface areas, such as car radiators, used for the dissipation of heat.

The research started some ten years ago when Professor J. W. Westwater, Head of the Department of Chemical Engineering at the U of I, decided to find out exactly what would happen to a fin immersed in a boiling liquid. The possibility of using fins in boiling liquids as a method of heat transfer had been left unexplored for close to twenty years because of an erroneous belief that fins could be used only with a low heat transfer coefficient. In other words, it was thought that in boiling liquids, heat would transfer from a metal fin either too rapidly or in a highly inefficient way. This would cause vapor boiling, or a pocket of air around the entire fin, and greatly reduce the heat transfer benefits of the fin. Experiments using microsecond photography disproved the belief in cases where the heat transfer coefficient is not uniformly distributed over the fins. It was also found that the shape of the fin influenced the distribution, and work began on finding the best shape for heat transfer.

Presently, both mathematical techniques and experimental methods are being used to optimize the geometric shapes, dimensions, and spacings of fins. Models tested include cylindrical spines, turnip-shaped spines, spheres, and disks. With each test, a fin is attached to a heating rod and immersed in a liquid. The metal is heated as far above the boiling point as possible while still maintaining the efficient performance of the fin. Results of the experiments are graphed and compared with mathematical computations. To date, the most

J. C. Shih, graduate student in the Department of Chemical Engineering at the University of Illinois at Urbana-Champaign, is preparing to photograph an experiment which will help him in his attempt to optimize the design of fins used in boiling liquids. Heat transfer from the fin to the boiling liquid is being studied in the experiment. The close-up shows vapor boiling on a spherical fin, a condition which does not allow the heat to transfer efficiently from the fin to the liquid. Other shapes used more successfully are cylinders, disks, and cones.

successful shape used has been the "Christmas tree" fin designed by graduate student J. C. Shih. This fin consists of three disks of graduated size attached to a cylinder. Its performance has been 300 to 400 percent better than that of the straight cylinder, the shape used in early experiments. One reason for the gain in efficiency is the increase in surface area on the "Christmas tree." Futhermore, the "Christmas tree" is strong and easy to manufacture, making it economically superior to some of the other designs tested.

Despite the success of the "Christmas tree," the researchers are continuing to look for a fin design that will suit any and all conditions of heat transfer. When such a design is found, it is expected to have a variety of applications in situations where extremely clean liquids that will leave no deposits on the fins are used. These situations include boiling-water nuclear reactors and large commercial air conditioners. In nuclear power plants, the efficient heat transfer gained through the use of fins could lead to more power generated by smaller, less expensive reactors. In large commercial air conditioners, the size of the units could conceivably be decreased through the use of fins in the evaporating sections of the machines.

With each success in the laboratory, the researchers come closer to finding the best fin for practical applications, and while the search continues for the most efficient fin, Mrs. Paul will have to look elsewhere for someone to help her prepare her fish sticks. ●

WATER, WATER EVERYWHERE

The Fourteenth Water Quality Conference, sponsored jointly by the Department of Civil Engineering at the University of Illinois at Urbana-Champaign and the Illinois Environmental Protection Agency, will be held February 9–10, 1972, at the U of I. Entitled "Ground Water Quality and Treatment," the conference is planned for engineers and scientists in education, government, industry, and private practice, and for water and wastewater works managers and operators. Further information on the conference may be obtained by writing to V. L. Snoeyink, Assistant Professor of Sanitary Engineering, 3230 Civil Engineering Building, the University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

WATER STUDY BRINGS TEN-GALLON TRIBUTE

Ven Te Chow, Professor of Hydraulic Engineering in the Department of Civil Engineering at the University of Illinois at Urbana-Champaign, has been named an honorary citizen of Texas by Texas Governor Preston Smith.

Professor Chow has served as an adviser to the Texas Water Development Board during the past three years, assisting implementation of the $10 billion Texas Water Plan. The plan calls for import of Mississippi River water to western Texas and New Mexico through a system of aqueducts and nuclear-powered pumping plants. ●

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VOL. 13, NO. 4, DECEMBER 1971

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inside outlook:

STUDENTS DESIGN URBAN VEHICLE
INHALATION ANESTHESIA MACHINE DEVELOPED
WATER QUALITY CONFERENCE PROCEEDINGS PUBLISHED
TWO REPORTS ADDED TO CRS SERIES
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ROLLIN' ALONG

In an attempt to get things moving as efficiently and as fast as possible, two student groups at the University of Illinois at Urbana-Champaign have combined their efforts for design of an entry in the 1972 Urban Vehicle Design Competition (UVDC). The groups, originally working on separate design proposals, have put their heads together and come up with plans for an alternating current hybrid electric vehicle with a Wankel engine as a prime mover.

The UVDC, an off-shoot of the cross-country Clean Air Car Race, is seeking entries designed for use in the urban centers of the 1980s. Entries are to be completely student designed and constructed, but industrial participation in funding of the project is permitted. In 1972, the UVDC entries will be judged in an urban setting instead of racing across the country.

U of I engineering students have been working on the project for close to a year, and about thirty of these students are receiving course credit for their efforts. Keith Erickson, a graduate student in the Department of Electrical Engineering, is the project director. This summer, representatives of the combined group presented a paper on their design at a national UVDC symposium, held at the University of Toronto, Ontario, Canada. Now the group is planning actual construction of a prototype model, with an eye toward getting the vehicle out on the streets by early spring. The national competition will be in August. ●

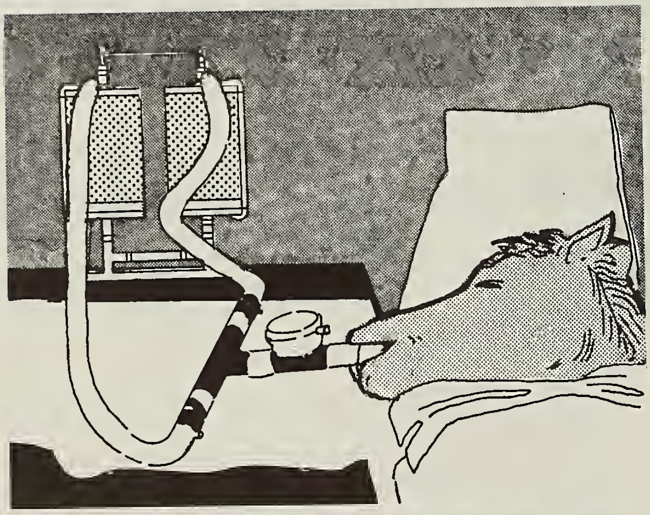
A REAL KNOCKOUT

Veterinary medicine and engineering — strange partners, you say. However, work being done at the University of Illinois at Urbana-Champaign has shown that the two disciplines are very compatible. Cooperative research between the Department of Veterinary Clinical Medicine and the Department of General Engineering has to date produced a prototype model of an anesthesia machine for large animals and has initiated development of a large animal respirator for use during lengthy surgical operations.

The research has involved a number of undergraduate engineering students under the guidance of H. J. Sprengel, Assistant Professor of General Engineering, and Dr. J. C. Thurmon, Associate Professor of Veterinary Clinical Medicine. It originated when Professor Sprengel, in an attempt to bring his students in contact with engineering problems posed by people in other fields, called on the Department of Veterinary Clinical Medicine. Dr. Thurmon, anesthesiologist at the University's Large Animal Clinic, responded with requirements for an inhalation anesthesia machine. Three undergraduate students in the Department of General Engineering then became interested in the problem as a topic for their senior design course.

The first step toward development of the prototype model was a survey of a wide sampling of veterinarians to find out exactly what features would be most important in design of the machine and whether there is a demand for such a machine. There seemed to be a need for an inexpensive, lightweight machine that could be carried to the patient and adapted to a variety of large animals, from horses to hogs.

Portability was an extremely important factor in design of the model because there is currently no equipment suited for field use with all sizes of animals. Most present machines are of limited capacity, making it necessary for different machines to be used on different size animals. This is partially due to small internal



The drawing shows testing of an inhalation anesthesia machine for large animals at the Large Animal Clinic of the University of Illinois at Urbana-Champaign. Still in the prototype stage, the machine was designed and constructed in the Department of General Engineering of the U of I, with help from the Department of Veterinary Clinical Medicine. It is lightweight, portable, and can be used on a wide variety of large animals. Development of the machine is one of a number of projects being carried out cooperatively by the two departments.

diameters in the circle tubing. The small diameters create high internal resistances for breathing and many machines have inadequate capacities for the air exhaled by larger animals. All such machines are closed gas systems. Therefore, the engineers were faced with the problem of increasing internal diameters and providing variable capacity, while at the same time keeping the machine portable and the total volume from being too great.

To keep expenses low and to maintain the possibility of building another machine, the model was designed using easily obtainable parts. The final model consists of two soda lime canisters set vertically side by side. The main plumbing and Y-piece are made of polyvinylchloride tubing that is of a slightly larger diameter than the tubing used in existing machines. Tests have shown that this larger diameter tubing means less resistance to flow, and it is thought that the low resistance may reduce the degree of variable capacity required. The entire collection of components is mounted on a plywood base with adjustable clamps attached to a steel rod framework. A precision vaporizer is mounted on the base. The machine is light-weight and can be transported in an ordinary automobile.

An important feature of the model is a device built to monitor breathing. This device, developed by another group of engineering undergraduates, consists of a small electrical amplifier and a speaker mounted in a section of the rebreathing tubing. The passage of air in the tubing is amplified and heard over the speaker. The device monitors both inhalation and exhalation and requires no energy from the animal. A mechanical monitor using a diaphragm that whistles with the passage of air has also been built, and cooperative work is being done on development of a heart monitoring device.

Other work now underway includes development of a prototype model of a power respirator for large animals. Presently there is no such machine made specifically for large animals — one which will artificially respirate these animals during lengthy surgical procedures. Dr. Thurmon has again suggested requirements for the prototype design, and it is hoped that current efforts will produce an economical model that will facilitate major surgery on large animals, including open heart surgery.

The anesthesia machine has been successfully tested in surgical operations at the Large Animal Clinic, giving the engineers a chance to see their project through to the end. And they have the added benefit of getting the test results straight from the horse's mouth. ●

SOLUTIONS TO VIRUSES IN SOLUTION

Proceedings of the Thirteenth Water Quality Conference, "Virus and Water Quality: Occurrence and Control," have been published by the Engineering Publications Office of the University of Illinois at Urbana-Champaign. The conference, held last February at the U of I, was sponsored by the Department of Civil Engineering (in cooperation with the Division of University Extension) and the Illinois Environmental Protection Agency.

Conference papers were presented by experts in their particular fields and include reviews of the current state-of-the-art and presentations of original studies. Knowledge in the following areas was updated: the properties of human enteric viruses and their detection, occurrence, and survival; diseases and epidemiology; and removal by water and wastewater treatment processes.

The proceedings may be purchased for $4.50 from the Engineering Publications Office, 112 Engineering Hall, College of Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. Payment should accompany your order. ●

DECISIONS, DECISIONS

Who made that decision and how did he make it? Perhaps nowhere is this question as vital as in the construction industry. Here routine, day-to-day decisions have a profound and immediate effect on capital, labor, materials, equipment, and information — the lifeblood of the company. These major decisions are often made informally, if not casually. This is partially due to poor information flow and partially to a lack of information about the actual decision making process.

A recent report in the Construction Research Series of the College of Engineering at the University of Illinois at Urbana-Champaign provides an innovative method of looking at the decision-making process — a method which offers new insight into the efficiency and correctness of construction management decisions. The authors, graduate student J. M. Kaiser and Professor R. W. Woodhead of the Department of Civil Engineering, have defined forty-three management functions which are common to all construction firms, regardless of size or volume. These functions are linked together to form decision networks which identify the functions and the responsibilities for concise, efficient decision making. In addition to the detailed definitions of management functions, the report, "A Decision Network Approach to Construction Management," provides ten examples of decision networks typical of the construction industry.

Copies of the 150-page report, CRS 15, are available from the Engineering Documents Center, 208 Engineering Hall, College of Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801, at a price of $4.00. If you are having difficulty deciding whether or not to obtain a copy, maybe one would make your next decision easier. ●

ANYONE FOR SIXTEEN?

Lining up right behind number fifteen, the sixteenth report in the Construction Research Series of the College of Engineering at the University of Illinois at Urbana-Champaign is now available. Entitled "Queuing Models for Production Forecasts of Construction Operations," CRS 16 covers production rate forecasting in the construction industry by way of mathematical models.

Common sense methods of production forecasting have often proven to be unreliable in aiding contractors to improve planning and scheduling functions. In this report, via the general-purpose-model method, the authors illustrate how a single mathematical model can be used to measure the productions of all operations which have the same abstract representation. An explanation of the simple-single-server queuing system is presented using a shovel-truck excavation operation as the frame of reference. A quick and easy to use method for obtaining the production forecast for this hypothetical excavation

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ORDER FORM FOR NEW PUBLICATIONS

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The following new publications have been added to the Construction Research Series:

☐ CRS 15, *Decision Network Approach to Construction Management* by R. W. Woodhead and J. M. Kaiser. *$4.00.*

☐ CRS 16, *Queuing Models for Production Forecasts of Construction Operations* by A. C. Brooks and L. R. Shaffer. *$3.00.*

Other Publications:

☐ Catalog, *A Listing of Engineering Publications, 1904–1971. No charge.*

☐ *Engineering Calendar.* A weekly calendar of seminars and discussions at the University of Illinois at Urbana-Champaign. *No charge.*

☐ *Men and Ideas in Engineering,* 58 photographs, 10 diagrams, 164 pages. Hard-bound, *$5.00;* paperback, *$1.50.**

Send with remittance to Engineering Publications, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. Payment must accompany orders of less than $5.00.

* Illinois residents please add 5 percent sales tax.

operation is also given. With the aid of CRS 16, contractors can now apply the cyclic queuing theory to a variety of practical problems using a procedure that does not require knowledge of the mathematical rigor of that theory.

Copies of CRS 16, by A. C. Brooks, Instructor in the Department of Civil Engineering, and L. R. Shaffer, Deputy Director of the U. S. Army Construction Engineering Research Laboratory, can be purchased from the Engineering Document Center, 208 Engineering Hall, College of Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801, at a cost of $3.00. So, if your problems concern planning and scheduling, be first in line for CRS 16. Payment should accompany your order. ●

PEOPLE AND PLACES

Dean **Daniel C. Drucker** of the College of Engineering at the University of Illinois at Urbana-Champaign has received the M. M. Frocht Award of the Society for Experimental Stress Analysis. The award, "for the highest achievements in education in experimental mechanics," was presented at the society's spring meeting. Dean Drucker, a civil engineer, is a past president and honorary member of the society.

Professor **Charles E. Taylor** of the Department of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign has been awarded the M. Hentenyi Award by the Society for Experimental Stress Analysis. The award, named in honor of a founder of the society, is presented annually for the best paper published in experimental mechanics. The paper, "A Multiple-Pulse Ruby Laser System for Dynamic Photomechanics: Applications to Transmitted and Scattered Light Photoelasticity," was written by Professor Taylor, I. M. Daniel, and R. E. Rowlands, who received his Ph.D. in Theoretical and Applied Mechanics from the University of Illinois in 1967. Rowlands and Daniel, who are at the Illinois Institute of Technology, also received awards.

Professor **Seichi Konzo** of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign has retired after forty-four years of continuous service on the U of I faculty. He began his career in 1927 as a research graduate assistant and most recently served as associate head of the department. Professor Konzo's pioneering research in air conditioning in the 1930s preceded the commercial development almost two decades later.

Nathan M. Newmark, Head of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign, will be presented with an honorary membership in the American Society of Mechanical Engineers at the group's winter meeting. Professor Newmark, whose specialty is structural engineering and engineering dynamics, will be the first engineer from the U of I faculty to receive an ASME honorary membership. ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL.13, NO.5, JANUARY 1972

inside outlook:

ENGINEERING OPEN HOUSE SCHEDULED
AGRICULTURAL WASTE TREATMENT RESEARCH
THE EMPLOYMENT PICTURE REVIEWED
1971 RESEARCH IS SUMMARIZED
ENGINEERS PROBE ATOM NUCLEI

FROM TELEGRAPHY TO HOLOGRAPHY

In 1906 the Department of Physics in the College of Engineering at the University of Illinois at Urbana-Champaign opened its doors to the public in a showing of departmental equipment, and Engineering Open House was born. The small 1906 exhibit consisted of displays of apparatus in the fields of light, sound, wireless telegraphy, and other electrical operations.

On March 10 and 11, 1972, the College of Engineering will open its doors for the forty-fifth time, offering visitors an inside view of what is happening in all the departments of the College. Student, departmental, industrial, and special exhibits will show every facet of engineering research and education, offering something that will interest almost everyone. For example, wind tunnels in the Department of Aeronautical and Astronautical Engineering will be available for inspection, and a holographic display will take place in the Department of Electrical Engineering. The student-built car to be entered in the Urban Vehicle Design Competition will be on view, all teaching laboratories will be open, and a special guidance display will be set up by the Associate Dean's Office. Many exhibits will reflect the theme of the 1972 Open House, "Engineering — Key to Survival," which was chosen because of the progress engineering has made in improving our quality of life.

Engineering Open House is the largest student-directed program in the College of Engineering. Student committees are responsible for the entire project, from planning to publicity to the setting up of displays. This year's Open House chairmen are Pam Calvetti, a senior in the Department of Aeronautical and Astronautical Engineering, and Michael Van Blaricum, a senior in the Department of Electrical Engineering.

Open House exhibits and demonstrations attract people with a wide variety of interests, from those who are just plain curious about engineering to those who have a specific interest in the College as a center of research and training for future engineers. High school students with an eye toward a future in engineering have a rare chance to find out what it's all about. If you would like to attend Engineering Open House, you are cordially invited. For additional information, write to Engineering Open House, Room 300, Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

AGRICULTURAL WASTE WATCHERS

Pollution is most often thought of as an urban problem, with industrial smog and inadequate sewage disposal facilities plaguing most cities. However, the problem is not exclusively an urban one. Agricultural pollution has been receiving increased attention from state and local environmental agencies, and research in the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign is looking into improving treatment and disposal methods for agricultural wastes.

D. L. Day, Professor of Agricultural Engineering, has been working for a number of years on the adaptation of oxidation ditch treatment to livestock wastes. Contributions to the project have come from the Department of Civil Engineering and the Department of Animal Science in the College of Agriculture.

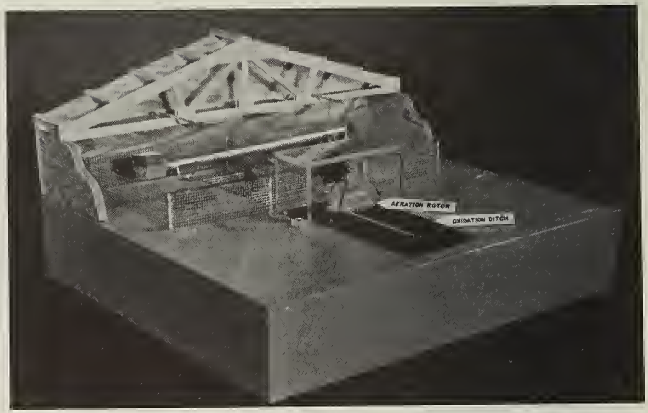
In keeping with the current trend toward housing livestock inside buildings, Professor Day and his associates have been experimenting with slotted-floor buildings with under-floor waste collection pits. Housing with under-floor collection pits is in itself a method of abating stream pollution since the waste material is contained and rainwater cannot wash through it, carrying it into streams. When the process is taken a step further, aerobic treatment is used for biological stabilization of organic matter in the liquid wastes. Aerobic treatment reduces the odor and the oxygen demand of the waste, making it more desirable for storage and for spreading on land as fertilizer.

The waste treatment system under study consists of a slotted-floor livestock building which is modified to include an oxidation ditch underneath. The ditch consists of a waste collection pit which is divided into channels. Aeration and circulation are accomplished through the use of a rotor, much the same as in many municipal sewage treatment plants in Europe. Labor can be greatly reduced by allowing the oxidation ditch liquid to flow by gravity into a non-overflow aerobic lagoon. Disposal of surplus materials can be made on land by irrigating the lagoon at a convenient time. This system is a low-odor, low-labor, waste management system from animal to field.

Although the oxidation ditch is a vast improvement over previously used methods, the researchers do not yet find it ideal. Experiments with in-building oxidation ditches are taking place on the U of I farms, and various types of aeration equipment are being tested. Problems to be wrestled with include expensive operation of the aeration rotor, maintenance of the rotor bearing, control of foaming, and the high concentration of nitrates in the waste after aerobic treatment.

One possible answer to the expense problem involved in operation of a livestock waste treatment system may lie in a recycling process now under investigation. Recently it was discovered that swine wastes from an oxidation ditch produce a material that contains a high level of protein. The liquid from the oxidation ditch is sieved to remove hair and undigested corn seed coats. Then the liquid that passes through the sieve is centrifuged, reducing the liquid volume by 85 percent. Crude protein content of the solids obtained is about 75 percent on a dry weight basis. Possibilities of refining and using the processed wastes as a swine feed supplement are being explored, with some refeeding experiments now underway. Research is expected to continue until the feed supplement meets Federal Food and Drug Administration standards. If standards are met and the hurdle of public acceptance is surmounted, the recycling process could conceivably eliminate costly and time-consuming waste storage and disposal, while at the same time providing a protein-rich feed supplement for livestock.

A number of related projects are going on in the Department of Agricultural Engineering, all aimed at improving the rural environment. Even though pollution problems have reached into almost every area of our lives, there are people working to solve them and to create a better quality of life, in the city and on the farm. ●



Experiments with improved methods of agricultural waste treatment and disposal conducted by the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign have used enclosed livestock buildings, similar to the model shown, for the installation of in-building oxidation ditch waste treatment systems. In these systems, aerobic treatment is used for biological stabilization of organic matter in the liquid wastes. This method of treatment reduces the odor and oxygen demand of the waste, making it more desirable for spreading on the land as fertilizer.

IT'S GETTING BETTER ALL THE TIME

Things are not as bad as they seem. According to the Associate Dean's office of the College of Engineering at the University of Illinois at Urbana-Champaign, the employment picture for engineers, when brought into focus, is much brighter than one could be led to believe from the press. Graduates of the College have met with far more success in obtaining employment than has been generally reflected by the news media, and are more successful in finding jobs to fit their talents and training than engineering graduates nationwide.

At the bachelor's level, 12 percent of last year's U of I engineering graduates reported themselves as unemployed in June 1971, but a check in September 1971 indicates that less than 5 percent are unemployed and the salaries received remained about the same as last year (averaging $872 per month). When stacked up against graduates in other areas, engineers fared very well in the job market, even though the employment situation is not as good as last year.

A resurvey of engineers who received advanced degrees in 1970–71 was also quite encouraging. Of 162 who received doctorates, only 7 reported themselves still available, and of these, 5 were foreign students. Of 343 who received master's degrees, 14 reported still available, and of these 9 are foreign students and 1 is traveling in Europe. Twelve others did not reply.

Of the 162 students who received doctorates from the College of Engineering last year, 61 are employed in industry. Eleven are with the armed forces, 35 are teaching, 27 are continuing training in postdoctoral study, and

21 are foreign students who returned home. In physics, which is part of engineering at Illinois and a field where employment has fallen, only 1 out of the 50 who received doctorates last year is now available.

Of the students who received master's degrees in engineering fields at Urbana-Champaign last year, 111 are working with industry, 50 are with the armed services, 5 are teaching, 22 are foreign students who returned home, and 125 are in graduate school — including 62 physics students who seldom stop their training at the M.S. level. Three others are in the Peace Corps and 1 is in medical school.

So, as gloomy as things may sometimes seem, the job prospects for engineering graduates of the University of of Illinois at Urbana-Champaign look brighter than most, and things seem to be getting better all the time. ●

SYMPOSIUM GETS INTO MOTION

A symposium entitled "Incremental Motion Control Systems and Devices" will be held March 27–31 at the University of Illinois at Urbana-Champaign. The symposium will be sponsored by the Department of Electrical Engineering in cooperation with Warner Electric Brake and Clutch Company, Beloit, Wisconsin, and Westool Limited, Durham, England. For further information about the symposium, contact M. E. Krasnow, Coordinator of University-Industrial Relations, College of Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

THE SUMMARY OF '71

The Summary of Engineering Research 1971, which describes the research program of the College of Engineering at the University of Illinois at Urbana-Champaign, is now available. The *Summary* describes briefly the more than six hundred research projects conducted in the College of Engineering including the Department of Physics, and the Department of Computer Science of the Graduate College.

Capsulized project descriptions, names of sponsors and investigators, and federal contract numbers are included in the *Summary*, along with an extensive listing of faculty publications.

Copies of the *Summary* are available free to students and faculty members of the University of Illinois and for a dollar handling fee for persons outside the University. Copies may be obtained from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. Payment should accompany your order. ●

FOUNDATIONS OF FISSION

What's inside the nucleus of an atom? One way to find out is to split the nucleus and then take a look. This is exactly what is being done in a continuing research program at the University of Illinois at Urbana-Champaign.

Under the direction of M. E. Wyman, Professor of Nuclear Engineering and Physics and Chairman of the Nuclear Engineering Program, and Bernard W. Wehring, Associate Professor of Nuclear Engineering, the research centers on the fission, or splitting, of uranium-235, the fuel used in nuclear reactors. The researchers are developing useful data to facilitate nuclear engineering applications requiring the safe, reliable, and economic exploitation of nuclear energy.

At present, the most visible application of nuclear engineering technology is found in the area of electric power production. Although reactor systems have been built and successfully operated, a complete understanding of fission has not as yet been achieved. The U of I research is intent on improving methods for reliably predicting the performance characteristics of fission assemblies through a greater knowledge of the fundamental fission process.

Reactor neutron beams are utilized to study the fission process. These beams are generated by the Illinois Advanced TRIGA, an above-ground tank-type reactor. The studies involve the measurement of radiation coincident with fission.

In a reactor, U-235 nuclei are split by neutrons. This nuclear fission breaks down the large uranium atom into two smaller elements called fission fragments. Energy is released in the form of radiation yielding beta, gamma, and x rays. The researchers are studying the fragments and radiation emitted by those fragments to determine the distribution of new elements produced during fission.

They measure the electrons, x rays, and gamma rays emitted from fission. The x-ray energy is unique for each element. Like a fingerprint, no two elements have the same energy radiation. By identifying the energy of the x ray, the fragments created during the fission process can be identified. Knowledge of the x-ray distribution can be used to determine the distribution of elements produced during nuclear fission. Knowledge of the gamma ray and electron distributions can be used to determine information about the nuclear structure of the fragments.

Details of the process and particles of fission increase the knowledge and safety of reactor performance. For example, ecologists concerned with "leakage" of fission fragments into the environment can be assured that proper shielding has been designed for the specific profile of fission particles emitted by the reactor pile. Or, procedures for an accident, such as loss of coolant, can be anticipated with precise knowledge about fission.

Work thus far at the U of I has produced unique data on the yield of fission fragments and the radioactivity of these fragments. These data are used to learn more about the fission process, the properties of fission, and the particles given off in fission. With information from related investigations, this knowledge in turn can be used to develop new types of reactors for power production as well as refining and creating specific uses in engineering, industry, medicine, and agriculture. ●

PEOPLE AND PLACES

Professor **Elwood F. Olver** of the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign has been advanced to the grade of Senior Member in the American Society of Agricultural Engineers.

The American Society of Mechanical Engineers has presented its Heat Transfer Division's Science Award for 1971 to Professor **B. T. Chao** of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign.

Two members of the civil engineering faculty of the University of Illinois at Urbana-Champaign have been honored by the American Society of Civil Engineers. Professor **Edward R. Holley** shares the Karl Emil Hilgard Hydraulic Prize, the society's highest award for a paper published in the field of hydraulic engineering, with Professor D. R. F. Harleman of the Massachusetts Institute of Technology and Professor H. F. Fischer of the University of California at Berkeley. The paper presents an analysis of rates at which pollutants become mixed in estuaries, and explains important conditions in determining how fast pollutants will spread. Professor **Kam Wu Wong** has received the Walter L. Huber Research Prize awarded to younger men who have made early accomplishments in civil engineering and who can be expected to continue fruitful careers in research. He was honored for his original research on geometric calibration of television mapping systems.

Two members of the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign have been honored with the grade of Fellow, the highest honor of the Institute of Electrical and Electronics Engineers. Those honored are Professor **William R. Perkins** and Professor **Robert T. Chien.** Sixteen U of I faculty have now been accorded this honor.

William C. Ackermann, Chief of the Illinois State Water Survey, has been installed as National Director of the American Society of Civil Engineers. ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 13, NO. 6, FEBRUARY 1972

inside outlook:

WEATHER STUDIES IN ST. LOUIS
A NEW MECHANICAL ENGINEERING LABORATORY
A THERMOMETER FOR LOW TEMPERATURE STUDIES
LIVESTOCK WASTE MANAGEMENT CONFERENCE SLATED
INDUSTRIAL RESEARCH ASSISTANTSHIP PROGRAM

EVERYBODY TALKS ABOUT IT

Into each life some rain must fall, and if you live in or near an urban area, you probably think you've been getting a little more than your share, along with a lot of hot, still summer days. The reasons behind increased rain and unpleasant weather within and downwind of large metropolitan areas are the object of a major five-year field study being conducted by scientists, engineers, technicians, and students from the Illinois State Water Survey, located at the University of Illinois at Urbana-Champaign. Entitled Metromex, which stands for Metropolitan Meteorological Experiment, the project involves detailed rain and weather measurements and observations, at ground stations and in the air, to pinpoint the location and amount of various rain changes in the St. Louis area. With two and one-half years of preparation behind them, the researchers, under the direction of Stanley A. Changnon, Jr., Head of the State Water Survey's Atmospheric Science Section, have now started collecting data.

Survey scientists began studying urban effects on rainfall about ten years ago. From historical records for Chicago and St. Louis, they found sizable increases in rainfall immediately downwind of the two cities. The increases have occurred during the last twenty to thirty years, mostly during the summer months. These increases in rainfall and changes in related weather conditions are considered great enough to suggest that information on how these alterations are actually produced may be of vital interest to those concerned with the weather and its effects. From a scientific point of view, knowledge of how a city influences its precipitation can aid in understanding ways of modifying precipitation intentionally. In an urban area, more precipitation can cleanse the air of existing pollutants. Downwind of the urban area rain increases may have considerable impact on agricultural and hydrologic interests.

Meteorologists agree that four factors, either acting together or separately, are probably responsible for urban-related rainfall increases. It is hoped that Metromex will help to determine which of these factors are actually responsible and how they work to modify natural rainfall. Major metropolitan areas are warmer than surrounding areas, and the upward release of heat provides vertical motions to air over the city. Vertical air motions are needed to produce rainfall. Secondly, many structures comprising a city usually serve as a barrier for the low-level wind flow, and this provides a means of lifting the air much the same as a mountain, also resulting in vertical air motions. A third possible reason for urban-related rainfall increases is the emission of various small particles from combustion processes in the cities. Certain of these very small particles can act as condensation and ice nuclei — that is, small particles which attract water vapor and grow into raindrops. Finally, the discharge of large volumes of water vapor from industrial processes plays an important role, since water vapor is needed in the development of clouds and precipitation.

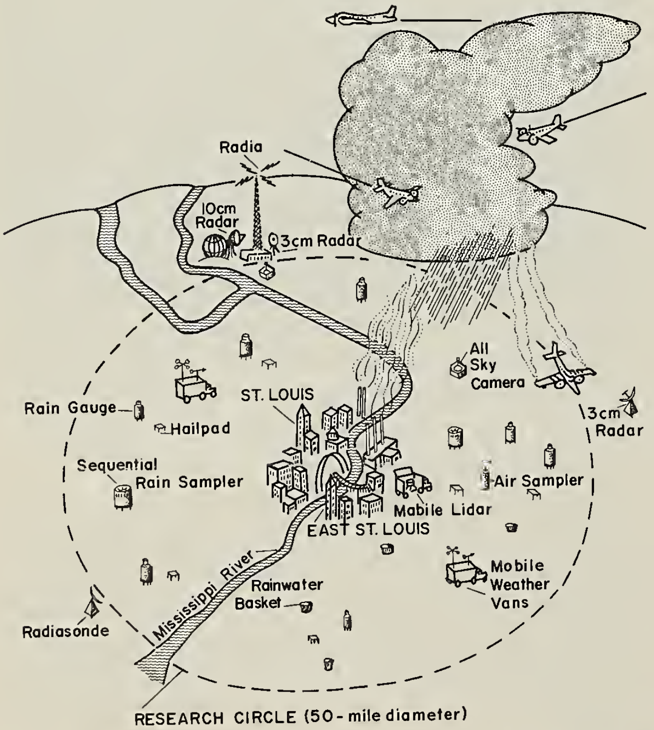
To gather data, the Water Survey has installed the world's largest recording rain gauge network. The 220 gauges are arrayed in a circular area having a diameter of fifty-two miles centered in downtown St. Louis. Each rain gauge site also includes a device to measure hail, and seventy-five sites have rainwater collection baskets to obtain water samples for chemical analysis of pollutants in rainfall.

Seven weather stations have been installed within the study area to measure and continuously record surface temperatures, humidity, and winds. At four other locations, instruments to record thunder, atmospheric electricity potential, and raindrop size have been installed. Two types of radar weather systems, developed especially for rainfall and cloud studies, are used to indicate where precipitation cells develop and how the intensity of these cells changes as they move across the metropolitan area.

Cloud cameras take continuous pictures of the St. Louis cloud cover, and research aircraft are used to study atmospheric conditions at and below the cloud base.

Steady operation of the rain gauge network is planned for the five-year study period, but radar systems, weather stations, research aircraft, and the rainwater collection network will be operated only during the summer months. Additional project input is coming from scientists at the University of Wyoming, the University of Chicago, and Argonne National Laboratory. Although the project has been underway for just a short time, initial findings have helped the researchers pinpoint the rain cell locations in the St. Louis area and have determined that urban clouds are often different in size, number, and type of droplet content from clouds in other areas.

As the rain gauge network continues to do its job, researchers at the Illinois State Water Survey are finding out a lot more about the influence of urban areas on weather. When their studies are complete, maybe somebody will be able to do something about what everybody talks about. ●



This artist's rendering shows some of the equipment used in the world's largest rain gauge network, set up in the St. Louis area by the Illinois State Water Survey to help measure the effects of the metropolitan area on rainfall and related weather conditions. Operation of the network, which includes over 200 rain gauges, two radar sites, and a radio communications system, is part of a five-year field study being conducted by Survey scientists, engineers, technicians, and students. The study is expected to yield data which will be useful in many areas, including the planning of weather modification experiments in Illinois and other locations with a similar climate.

A LITTLE HELP FROM THEIR FRIENDS

Millions of dollars in borrowed equipment lent an air of uncanny authenticity to the five-level laboratory of the movie *The Andromeda Strain*. Many an engineering educator who saw the movie must have wished that he had comparable equipment for his students' laboratories. But with university laboratory development funds considerably smaller than Hollywood movie budgets, additional laboratories are often deferred in favor of other educational needs.

A case in point was the Mechanical Analysis and Simulation Laboratory in the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign. Need for the lab existed long before its development, which began three years ago. Initial funds were provided by the National Science Foundation, but the real angel of mercy was the Mueller Company of Decatur, Illinois. Without the Mueller Company, the lab would still be in the "wish" stage. When informed of the need for the lab, Mueller officials made only one stipulation before providing the funds — the lab was to be solely for student work.

The impact of the lab on students has been immediate. The lab allows 125 students a week to test classical theory against reality through individualized experiments. An analog computer allows simulation of a variety of dynamic systems and control conditions, offering students a third means of comparison. When a student "graduates" from the lab, he has compared classical theory, experimental situations, and computer simulations and knows the strengths and weaknesses of each.

According to professors Carl S. Larson and Richard E. Klein, who oversee the lab, it will be constantly changing, growing, and developing according to the needs of the students. So, with a little help from their friends, mechanical and industrial engineering students at the U of I are getting their feet wet before diving into their chosen professions. ●

OUT OF THE MOUTHS OF GRADUATE STUDENTS

A doctoral thesis written at the University of Illinois at Urbana-Champaign has given birth to a technical book with applications in many fields, including aerospace, chemical, nuclear reactor, and transportation technologies. The book is entitled "Optimal Control by Mathematical Programming."

Authors of the book are Professor Benjamin C. Kuo of the Department of Electrical Engineering at the U of I, and Professor Daniel Tabak of Rensselaer Polytechnic Institute of Connecticut at Hartford, who was a graduate student at the U of I under Professor Kuo. In writing the book, Professor Tabak continued his thesis project, which entailed bringing together from many sources material about optimal control.

The volume concerns the numerical solution of optimal control problems, presents basic concepts of mathematical programming, and describes techniques for implementing the solution for optimal control problems. Professor Kuo specializes in control systems, digital controls, and data sampling. ●

BABY, IT'S COLD

In order to learn more about nature, physicists observe and often create environments which seem far from natural. They work with temperatures so high that they disintegrate the atoms of a gas into ions, and so low that they approach the ultimate in cold. Low temperature studies may be the most exciting, and the most perplexing, of all physics. Near absolute zero, electrical current may flow without resistance, superfluids flow without viscoscity, and the properties of a material may be changed drastically by altering the temperature only a few thousandths of a degree.

To find their way around this wonderland of supercold, physicists use a thermometer instead of a compass. At nearly 500 degrees Fahrenheit colder than freezing water, where tiny changes in temperature are vitally important, a variety of specialized thermometers may be used. Practically all such thermometers share the disadvantage of needing recalibration each time they are cooled. Recalibration is a tedious operation requiring great care if measurements at different laboratories are to agree. To simplify such recalibration, a thermometer, which will measure temperature changes to one two-thousandth of a degree, has been developed at the University of Illinois at Urbana-Champaign by Professor Dillon E. Mapother of the Department of Physics and the Materials Research Laboratory, and by Roger P. Ries, graduate student in the Department of Electrical Engineering.

Unlike other devices used to measure at such low temperatures, the thermometer can be moved from place to place without recalibration, and it can serve as a standard to check other thermometers. It measures in the range of 459.13 to 456.69 degrees below zero Fahrenheit (1.1 to 0.3 degrees Kelvin), where very small temperature changes are important in various cryogenic phenomena.

The thermometer consists of an aluminum wire, a solenoid whose magnetic field affects the aluminum's superconductivity, and detection coils to reveal the superconducting condition of the aluminum. The unit used at the U of I is about one-fourth of an inch in diameter and two inches long, but it could be made smaller. Its operation is based on the fact that at extremely low temperatures, certain materials become superconducting, losing all resistance to electricity, and superconductivity can be affected by a magnetic field.

Superconductivity is a phase transition phenomenon like the boiling of water. Boiling, a transition from liquid to vapor, can be suppressed by increasing pressure of the vapor. The amount of pressure controls the liquid's temperature — as in a housewife's pressure cooker. Similarly, superconductivity can be suppressed by a magnetic field, and the amount of magnetic "pressure" can be used to regulate, or to indicate, the precise temperature at which the superconducting transition occurs.

Although we may never need Professor Mapother's thermometer to tell us whether or not to wear an overcoat, the device will be a boon to those physicists working with very low temperatures. ●

WHAT TO DO WHEN THE COWS COME HOME

The Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign has scheduled a Livestock Waste Management Conference, to be held March 1–2, 1972. Conference speakers will present current information on expected Environmental Protection Agency regulations, planning assistance which is available for livestock waste management systems, present control practices, and the economics of livestock waste management. Additional information may be obtained from the Livestock Waste Management Conference Supervisor, 116 Illini Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

PRODUCTIVE PARTNERSHIPS

Goals of industry and education often coincide, sometimes within one individual. Such is the case with the industrial research assistantship program of the College of Engineering at the University of Illinois at Urbana-Champaign, which funds graduate students working in a company's area of technical interest. Recently the program was expanded by the Andrew Corporation, Orland Park, Illinois; Zenith Radio Corporation, Chicago; and Magnavox Company, Fort Wayne, Indiana, program participants. The U of I has also added an industrial postdoctoral fellowship from the IBM Corporation, Yorktown Heights, New York.

Under the research assistantship program, a company provides $7,500 for each assistantship to cover salary, material, equipment, and other costs. The postdoctoral fellowship, which involves $10,000 annually, is similarly organized. Each student is selected by the University.

A new Andrew Corporation assistantship has been awarded to Benjamin P. Green, and continuations have gone to Edward L. Ostertag and Victor K. Tripp. All three are working in the University's Antenna Research Laboratory. Zenith Radio Corporation is supporting the work of Donald L. Helfrich, who is working in optical electronics. Under the new Magnavox Company research assistantship, Robert Kansy is working on electromagnetic waves on solid surfaces. The IBM Corporation post-doctoral research fellowship has been awarded to Tak H. Ming, who is working in the field of semiconductors.

Participating companies may employ their student assistant full time during summers. After graduation, several students have joined the staffs of firms which supported them in their research, matching a qualified researcher with a satisfied employer. ●

PEOPLE AND PLACES

Professor **James W. Bayne,** Associate Head of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign has been elected national President of Pi Tau Sigma, honor society for mechanical engineering students. He has been national Secretary-Treasurer of Pi Tau Sigma since 1959 and advisor to the U of I chapter since 1955. Professor Bayne will serve a three-year term as president. Pi Tau Sigma was founded at the U of I in 1915.

The first Phoenix Award of the American glass manufacturing industry has been presented to Professor **Fay V. Tooley** of the Department of Ceramic Engineering at the University of Illinois at Urbana-Champaign. The award recipient is selected by a jury of twenty-four industry leaders from award nominees proposed to *Glass Industry* magazine, a leading journal in the field.

Retired staff members of the Department of Agricultural Engineering were honored recently at a banquet given by their colleagues in the department. The emeriti professors honored were: **Emil W. Lehmann,** former department head; **Ray I. Shawl; Arthur L. Young; H. Paul Bateman; Deane G. Carter;** and **Harold H. Beaty.** Staff members honored posthumously were: **W. A. Foster; John H. Ramser; Keith H. Hinchcliff;** and **George E. F. Pickard.**

Professor **Raj Mittra** of the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign was the leader of a short course, Computer Techniques for Electromagnetics, given recently under the auspices of the Danish Engineering Society.

The American Concrete Institute has presented its Alfred E. Lindau Award to **Clyde E. Kesler,** Professor of Theoretical and Applied Mechanics and of Civil Engineering at the University of Illinois at Urbana-Champaign. The honor was presented for Professor Kesler's "outstanding performance and interpretation of research which has led to improved reinforced concrete design practice and to safer and more economical reinforced concrete structures." ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 13, NO. 7, MARCH 1972

inside outlook:

LEAD POLLUTION STUDY
UNDERGRADUATE RESEARCH FUNDING
ACI BUILDING CODE CONFERENCE
UPPER ATMOSPHERE OBSERVATORY PLANNED

REALLY HEAVY

What happens to the 300,000 tons of lead used annually in gasoline additives? The answer to this question and others will be sought through an intensive, interdisciplinary investigation of lead pollution and its causes, effects, and prevention, now getting under way at the University of Illinois at Urbana-Champaign.

The research will involve faculty from civil engineering, mechanical engineering, chemical engineering, aeronautical and astronautical engineering, forestry, animal science, chemistry, environmental biology, veterinary medicine, botany, zoology, agronomy, biophysics, economics, and other fields. The Illinois State Water, Geological, and Natural History Surveys, located on the U of I campus, will also be part of the project. Lead pollution and pollution by other heavy metals including cadmium, copper, arsenic, and mercury will be investigated through field exploration, laboratory experiments, and computer modeling. Emphasis will be on team research, teaching, and public service. Lead was selected as the primary pollutant for study because it is widely distributed as a result of automotive fuel consumption, and it is relatively immutable and simple to detect and measure.

Field studies will be on a 76-square-mile area including the Urbana-Champaign area and farmland north of it. Laboratory experiments will include controlled studies of pollution effects on plants and animals and of the movement of pollution-carrying water through soil. Data about the sources, movements, and effects of lead pollution will be fed into the University's computer facilities to provide a mathematical model of pollution and the environment. In this model, proposals for control or change can then be tested and explored with answers in seconds which would take decades in the natural ecosystem.

Thirty graduate students from various fields will work on the project as part of their thesis research, and undergraduates will be involved both directly and indirectly. Efforts of the entire research team will be supported by a National Science Foundation grant, and the project will take place under the auspices of the Environmental Studies Institute, recently approved by the U of I Board of Trustees. Once underway, the project will be a large-scale and intensive search into a weighty environmental problem. ●

UNDERGRADUATES UNLEASHED

Not since Isaac Newton's apple have classroom teaching aids in undergraduate engineering been inexpensive and readily available. Laboratories for undergraduate instruction have increased in both sophistication and expense. As a result, they have been limited to demonstrating ideas that were largely drawn from textbook material. The student with a creative idea, or the instructor with an innovative teaching technique, had to make do with available equipment, or not at all.

In the mid-sixties, the Bodine Electric Company of Chicago recognized this need and instituted the Bodine Fund for the express purpose of improving undergraduate instruction in the College of Engineering at the University of Illinois at Urbana-Champaign. Grants from the Bodine Fund allow the students to test their theories by designing and building their own equipment and by investigations pertinent to classroom work. Instruction is improved by bringing classroom theory into the region of practical experience.

Grants have been made for freshman projects, advanced undergraduate research projects, honors student projects, and open house displays which illustrate engineering principles in practice. The only limit to the use of the fund is the imagination of the students and their advisors. Some grants from the fund have been made to faculty members, but only to improve their classroom instruction. A number of the faculty have used the Bodine Fund to develop training aids and new techniques in teaching their courses.

Undergraduates, in using the Bodine Fund, have come up with some creative and unique projects. One senior project in 1969 was the design of a waste elimination device for small animals. Two students developed a workable model of an indoor toilet for dogs and cats. As a convenience for apartment dwellers, the project showed real merit. At least one manufacturer expressed commercial interest in the device.

Another project tested the use of synthetic bones in animals in an attempt to find a material that would not deteriorate when used in the body. Various ceramic materials were tested for reactions to long-term stress in a biological environment. The eventual product of this research will be durable prosthetics made from presently available materials.

This year, students have built a portable anethesia machine for veterinary use (*Outlook,* December 1971), and have studied sleep learning and built a machine for that purpose (*Outlook,* October 1971). Other studies sponsored by the fund this year were the removal of mercury from water by metal oxide absorption and the construction of a hemispherical radiant heat chamber for use in mechanical engineering.

If learning is facilitated by practice, the Bodine Fund has achieved its goal of improving instruction. Even if it is not, the fund has provided the engineering undergraduates with an opportunity to demonstrate what they can do, when given the chance. ●

GETTING TO KNOW YOU

The fourth annual Inner-City Engineering Orientation Program for black high school students will be presented July 9–22, 1972, at the University of Illinois at Urbana-Champaign. The purpose of the program is to acquaint participants with the various fields of engineering and with the type of effort involved in a college education. Included in the program will be tours, lectures, and opportunities to explore individual interests. Housing, meal, text, and supply costs are paid by the program. Professor David C. O'Bryant of the Department of General Engineering is heading the program. ●

Two seniors in a project design course, using equipment provided by the Bodine Fund, demonstrate a working model of a waste elimination device for cats and dogs. It is equipped with microswitches and relays, and sweeps waste products into household waste lines when the animal steps out.

DEALING WITH CONCRETE PROBLEMS

A conference on Changes in the ACI Building Code will be held at the University of Illinois at Urbana-Champaign on April 14 and 15. The program was developed with the assistance of practicing engineers and architects. The speakers are W. Gene Corley, Phil M. Ferguson, Emory Kemp, James G. MacGregor, N. M. Newmark, Chester P. Siess, and Mete A. Sozen. All are internationally recognized authorities in concrete building design.

Major topics to be discussed are bond and splices, torsion, shear, columns, slab systems, and seismic design. The conference is open to anyone with an interest in topics covered by the code, including engineers, architects, materials suppliers, inspectors, building authorities, quality control personnel, contractors, and university instructors. Planning of the conference is coordinated by the Department of Civil Engineering and the College of Engineering. For further information write Clyde E. Kesler, 2129 Civil Engineering Building, University of Illinois, Urbana, Illinois 61801. ●

SCIENTIFIC SUMMER SCHOOL

An intensive course in electronics for scientists who use electronic instruments will be scheduled for the thirteenth time next summer at the University of Illinois at Urbana-Champaign. It will be financed by a National Science Foundation grant and directed by the chemist who created it, Professor Howard V. Malmstadt.

While the course is offered during the summer to teachers and a small number of scientists from industry, medical centers, and other nonteaching organizations, it is available during the regular school year to undergraduate, graduate, and professional students at the U of I. ●

OBSERVATORY PROJECT GETS OFF THE GROUND

Looking up and ahead, scientists and engineers from the United States and Canada are setting their sights on a project that would enable them to have a better-than-ever view of the upper atmosphere. Construction of a $13 million Upper Atmosphere Observatory to study the relation of energy miles above the earth to weather, radio communications, and other phenomena on earth has been proposed by a group of six universities, including the University of Illinois at Urbana-Champaign.

Preliminary studies for the observatory were carried out at the U of I under the direction of Sidney A. Bowhill, Professor of Electrical Engineering. Other universities in the group, organized as the Upper Atmosphere Research Corporation, are Rice University, the University of Pittsburgh, Pennsylvania State University, Massachusetts Institute of Technology, and the University of Western Ontario, Canada.

The tentative site for the observatory is near the central or eastern U.S.–Canadian border, where, because of the earth's magnetic field, ionized layers of the upper atmosphere form a low-density "trough" which offers an opportunity for a variety of research capabilities not possible elsewhere. Magnetic storms may bend or push this trough so that instruments located under it can observe these changes and also can study conditions normally found only northward in arctic regions or southward in middle latitudes.

Phenomena such as electric fields, winds, the ionosphere at heights of 50 to 6,000 miles above the earth, and the relation of these to the atmosphere below and space above, will be studied by the Upper Atmosphere Observatory. While the general structure of the upper atmosphere has been sampled and charted with satellites, rockets, radar, and other devices, an understanding of what goes on there requires a facility capable of making a continuous record twenty-four hours a day. The planned observatory will provide such data, essential to the understanding of the behavior of the whole upper atmosphere and its effects on lower levels.

Work planned at the observatory is expected to greatly increase understanding in two specific areas — weather and long-distance radio communications. The earth's weather is determined by a dynamic system extending from ground level to many miles above the surface; a system needing extensive study for long-term weather predictions and possibly weather control. Long-distance radio communications are heavily influenced by phenomena in the upper atmosphere, and increasing communications needs require additional information about this area. While satellite radio relays are important in lower latitudes, synchronous satellites cannot be used above 75–80 degrees north.

The observatory, expected to be in operation in 1975, will use incoherent scatter radar, a new system developed within the last ten years. Its very high-powered signals can track and study rarefied gases and particles at extreme altitudes.

One of the unique aspects of the observatory is that it will be international and interdisciplinary, with a strong research and educational program involving resident and visiting scientists, engineers, and graduate students. Work in the areas of physics, chemistry, mathematics, electronics, and other sciences will be involved in the effort to understand the upper atmosphere in down-to-earth terms. ●

AND THE WINNERS ARE . . . .

Three students in the Department of General Engineering at the University of Illinois at Urbana-Champaign put their heads together recently and came up with a winning entry in the 1971 Engineering Student Design Competition sponsored by the James F. Lincoln Arc Welding Foundation of Cleveland, Ohio. The students are Ronald Rutger, Charles W. Fellman, and John A. Turner; they share a $250 fourth place award for their project "Elastic Springback in Rolled Sections Cold Formed in a Die." The Department of General Engineering has received $300 in recognition of the students' accomplishments.

Outstanding student achievement in the solution of engineering problems in the design of structures, manufactured products, or their components is recognized and rewarded by the annual competition. The winning U of I project was carried out under Professor Morris Scheinman and Charles F. Gebhardt, visiting lecturer in the Department of General Engineering. ●

PEOPLE AND PLACES

Richard E. Klein, Associate Professor of Mechanical Engineering, gave a series of lectures at Ciudad Universidad in Madrid, Spain, last month. The subject of the lectures, delivered to the Asociación de Investigación de la Construcción Naval, was the control and automation of ships.

Seven alumni of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign have been honored by that department's alumni association. Those who have received Distinguished Alumnus Awards are: **Clarence J. Gauthier**, Chairman and President, Northern Illinois Gas Company, Aurora; **Robert H. Page**, Chairman of the Department of Mechanical and Aerospace Engineering, Rutgers University, New Brunswick, New Jersey; **Charles E. Drury**, President, Hayes-Albion Corporation, Jackson, Michigan; **Armin Elmendorf**, President, Elemendorf Research Incorporated, Palo Alto, California; and **Seichi Konzo**, retired Associate Head of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign. Alumni Loyalty Awards have been presented to **Donald R. Bahnfleth**, retiring President of the Mechanical Engineering-Industrial Engineering Alumni Association at the U of I, and editor of *Heat, Piping and Air Conditioning* magazine, Reinhold Publishing Company, Chicago; and to **James W. Bayne**, Associate Head of the Department of Mechanical and Industrial Engineering at the U of I.

Three alumni of the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign have received the second series of Distinguished Alumnus Awards presented by the Electrical Engineering Alumni Association. The recipients are **Carl E. Asbury**, Assistant to the President, Southern Services Inc., Birmingham, Alabama; **John H. Bryant**, President of Omni Spectra Inc., Farmington, Michigan; and **Emerson A. Schultz**, Senior Vice-President, Illinois Power Co.

Nancy Jakse, a sophomore in the Department of General Engineering at the University of Illinois at Urbana-Champaign, and **Mark Schaefer**, a sophomore in the Department of Electrical Engineering, have been selected as Munich Exchange Scholars to study at the Technical University in Munich, Germany, next year under the auspices of the College of Engineering Honors Program. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 13, NO. 8, APRIL 1972

MAY 1972

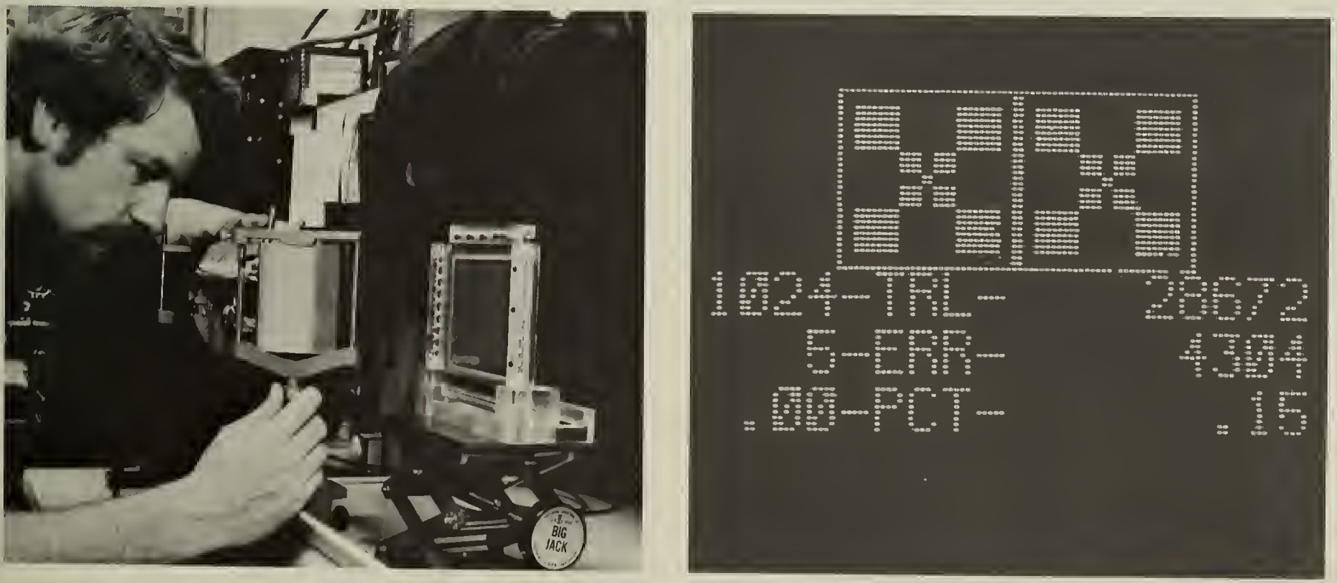
inside outlook:

EXPANDING PLATO
RURAL NITRATE POLLUTION STUDIED
NEW INFORMATION ON HUMAN RESPIRATION
STARQUAKES ON THE CRAB PULSAR

TODAY CHICAGO, TOMORROW . . .

A $10 million program which will take PLATO (the computer-based teaching system developed at the University of Illinois at Urbana-Champaign) all the way to Chicago is now in the works at the Computer-based Education Research Laboratory in the Graduate College. Development will include equipment and teaching programs for a minimum of fifteen college courses, eight community college courses, and reading and mathematics for two elementary grades. Operation of four thousand student stations is expected by the end of 1975, with PLATO serving three elementary schools and two community colleges in Chicago, plus two elementary schools, a community college, and the University of Illinois at Urbana-Champaign.

Initial work on the PLATO (Planned Logic for Automatic Teaching Operations) project was started in 1959 by Professor Donald Bitzer, head of the Computer-based Education Research Laboratory (*Outlook*, January 1969). The present PLATO system is centered in a large electronic computer at the University. The computer is capable of individually serving as many as four thousand students at one time. PLATO enables a large number of courses to be offered simultaneously, with each student progressing at his own speed. Each student communicates with the computer and carries on his work at a console, or student station, which has a display screen and a keyboard. The screen is a thin, flat display panel, recently developed



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W. J. Coates, Research Physicist in the Coordinated Science Laboratory of the University of Illinois at Urbana-Champaign, is operating an experimental apparatus used in the investigation of optical read-out techniques on plasma display/memory systems. The display panel was designed primarily as a low-cost replacement for a cathode ray tube in PLATO, the computer-based education system developed at the U of I. Because of its memory feature and digital operation, the display panel has shown great potential for use in other applications.

at the U of I. Unlike a television tube, it can be operated over ordinary low-cost telephone lines. When the computer is in full use, the estimated cost for each student is less than seventy-five cents an instruction hour for everything — equipment, computer lines, lesson preparation, and management.

During the past five years, more than 150,000 hours of instruction have been given by PLATO in courses from preschool to college graduate work. By 1975, PLATO will cover a lot more territory, and after that, maybe the world. ●

. . . AND OTHER LIVING THINGS

Water containing a high level of nitrate can cause baby pigs to turn blue. This is no laughing matter, however, because it results in death and the reactions are the same in other animals, including baby humans. The disease is called methemoglobinemia. It is caused when high concentrations of nitrate in the body are converted to nitrite, causing oxidation of the blood. The blood is prevented from carrying oxygen, and the result is suffocation.

Methemoglobinemia has been recorded in Southern Illinois, affecting animals living on farms with high nitrate levels in their water supply. Concern over this problem has led to a study, financed by the Illinois State Water Survey, the College of Agriculture, and a $600,000 grant from the Rockefeller Foundation, to determine the causes and extent of nitrate pollution in the water supply and to find methods to control the pollution and prevent it from becoming more extensive.

The objective of phase one of the study, headed by Walter Lembke, Associate Professor of Agricultural Engineering at the University of Illinois at Urbana-Champaign, is to use field studies to measure and predict the amount of nitrates in groundwater. From this, information on the extent of pollution by agricultural chemicals and fertilizers will be determined.

Chemical fertilizer, however, may not be the most direct cause of nitrate pollution. Nitrates are produced by the natural decomposition of organic animal and vegetable matter, and are also a by-product of food and wood processing. Nitrates from these sources are also carried into waterways and groundwater.

To determine if the source of the nitrate excess on Southern Illinois farms is from natural organic decomposition or from chemical fertilizers, Professor Lembke measured the relationship between chloride and nitrate in the soil and water. Both nitrate and chloride ions move freely in water. Since chlorides are commonly found in the decomposition of animal waste, it was theorized that their presence or absence should help pinpoint the source of the nitrate. If the primary source of nitrate is fertilizer, there should be no correlation between nitrates and chloride in the soil and water.

Results from two sample farms have shown a correlation between the chloride and nitrate content of the water, giving evidence that natural decomposition is the most likely cause of the high nitrate level. This does not prove that chemical fertilizer is harmless, however. Nitrogen levels in Illinois water have been rising steadily since one study began in 1951. Nitrogen use in the United States has increased from 378,543 tons in 1940 to 6,912,706 tons in 1969, with Illinois accounting for 9.1 percent of this use. At the very least, the use of nitrates in chemical fertilizer has increased the growth of plants and animals, whose waste in itself has been shown to be a problem.

When more information from this phase of the problem is gathered, the study will go into the socio-economic aspects involved. Answers will be sought to the problems of the type and level of regulation necessary to limit nitrate use, the necessity of government intervention to enforce the laws, and the communication processes that must be used to inform people of the problem.

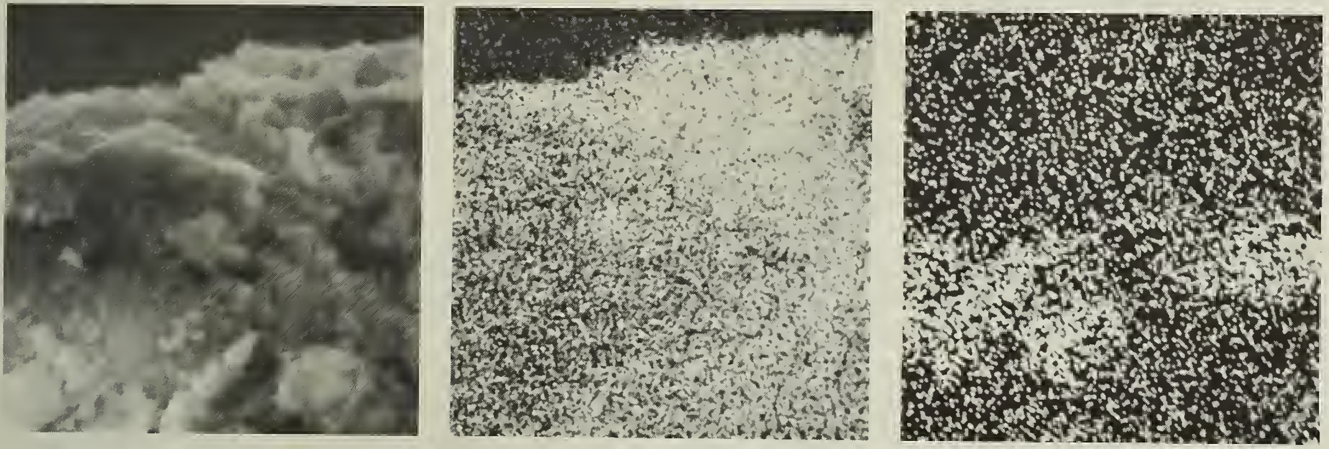
Finally, ways must be found to continue the increase of agricultural productivity while limiting the use of chemicals to stimulate growth. Although methemoglobinemia would be prevented, epidemics of hunger would be a poor trade. ●

EXHALIA

Space capsules and submarines are all built on the assumption, made by Lavoisier in 1775, that the body absorbs oxygen and produces carbon dioxide. This assumption is fine as far as it goes, but anyone spending an extended time in a submarine should plan to breathe very carefully.

A recent study has shown that, contrary to beliefs held for 200 years, there is more to the respiratory cycle than oxygen and carbon dioxide. The present concept is that nitrogen is expired in the same amounts that it is inspired. It is believed that nitrogen is metabolically inert in the body except under extreme pressure changes. It is common knowledge, however, that under great atmospheric pressure changes, nitrogen evolves from solution in the blood as bubbles causing decompression sickness, known to divers as "bends."

Research by John Cissik, graduate student in physiology, under the direction of Bruce Hertig, Professor of Mechanical Engineering and of Physiology and Director of



A scanning electron microscope examines a lead poisoned, alumino-sphere supported Co_3O_4 catalyst. The catalyst was exposed for 350 miles to the exhaust of a six-cylinder engine burning leaded fuel. The first photograph is a secondary electron image of the sectioned catalyst (700x). The second and third are nondispersive x-ray images of the same surface showing the cobalt and lead distributions, respectively.

the Ergonomics Laboratory at the University of Illinois at Urbana-Champaign, has shown this common assumption to be false.

Tests on human subjects under conditions of controlled diet and controlled exercise have proven that nitrogen is produced in the body. Under conditions of high exercise and high protein diet, nitrogen is exhaled in greater amounts than it is inhaled. The same effects are found under normal conditions to a lesser degree.

According to Cissik, applications of his research will be many and immediate. For long-term space missions, nitrogen must be taken into account in determining the amount of oxygen needed. Although higher concentrations of nitrogen in the atmosphere of the space capsule will not be harmful, nitrogen displaces the calculated amount of oxygen. Perhaps it will be necessary to redesign the chambers and to provide equipment to remove excess nitrogen. The same generalizations are applicable in the design of submarines, or any other small, self-contained environment.

Decompression tables for use in diving must also be recalculated. There is at present an unexplained percentage of decompression sickness developing with the tables currently in use. Taking the body's production of nitrogen into account could present an explanation for this.

Finally, all research on oxygen consumption and energy balance will be undermined. The factor of changes in nitrogen volume must be taken into account before accurate measurements of oxygen consumption can be made.

When the nitrogen factor is taken into consideration in the design of space capsules, astronauts will be able to breathe easier because of this inspiring research. ●

OLD TIMERS

The oldest radio stars most of us can remember date from about the time of Fibber McGee and Molly, Fred Allen, and Jack Benny. But even Jack, who counts his years at thirty-nine and has been on the air at least that long, is a relative newcomer to radio when compared to the youngest of another type of radio star, the Crab Pulsar.

The formation for the Crab Pulsar was recorded by Chinese astronomers in 1054 A.D., when a "guest star" was visible in the sky for twenty-four days. This guest star was an explosion called a supernova, caused by the gravitational collapse of a star like our sun. Although too cold and too small to be seen visibly today, the Crab Pulsar can be detected by the radio signals it sends out at regular intervals corresponding with its rotation rate.

Of the nearly sixty pulsars which have been discovered with the help of the radiotelescope since 1967, the Crab Pulsar seems to be the youngest and the most active, emitting signals thirty times per second. Signals from the Crab Pulsar do not exhibit absolute clocklike regularity, however.

Three times in the last two years astronomers have recorded speedups in the Crab Pulsar's signals. Erratic, irregular spin ups and spin downs indicating disturbances of a smaller nature on the star are commonplace, also.

Professors David Pines and Jacob Shaham of the Department of Physics at the University of Illinois at Urbana-Champaign have proposed a theory explaining the erratic behavior of the Crab Pulsar. Neutron stars are formed, like the earth, with a solid crust and a liquid core. They are so very dense, however, that the mass of the Crab Pulsar, which is comparable to that of the sun, is squeezed into a sphere only fifteen miles in diameter. If the earth were compressed to the same density, it would have a diameter of only 200 feet. The neutron star is subject to great stresses on its outer crust. Professors Shaham and Pines have proposed that the stresses create starquakes on the surface of the star, causing the irregular frequencies of the radio signals.

The crust of the star is extremely dense, melting only at temperatures of 100 billion degrees. As the star spins, it slows down, creating stresses too great for even this massive crust to withstand. When the stress reaches a certain point, the crust cracks, relieving the pressure and causing the spinning to speed up once again. These are called macroquakes, and can be expected every few months. The smaller irregularities in the Crab Pulsar's radio signals are caused by microquakes. Microquakes occur when the radio star wobbles on its axis. The extent of the wobble can be estimated by comparing the rates of macro- and microquakes.

Closer to home, a relationship has been noted between earthquakes and the amount the earth wobbles on its axis. The physicists are currently applying their starquake model to earth, to see whether it provides a natural explanation for the periodicity of earthquakes.

The Crab Pulsar's signals may give clues to the internal workings of the earth. It must be said, however, that its periodic radio signals will never attain the popularity of Jack Benny's "Love in Bloom." ●

EXTRAS

The Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign will share a $30,000 grant from the Celanese Chemical Company with two other departments at the University. The Departments of Agricultural Economics and Animal Science will aid in studying the use of chemical preservatives in comparison with other methods of storing and conditioning high-moisture corn.

The Eastman Kodak Company has given the Coordinated Science Laboratory $10,000 for research in physics. The award was the only one in the field of physics to be made by Kodak in a nationwide program. ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 13, NO. 9, MAY 1972

inside outlook:

POSSIBILITIES FOR WINTER CONSTRUCTION
CALIFORNIA EARTHQUAKE SIMULATED IN ILLINOIS
RADIO WILL CELEBRATES FIFTIETH ANNIVERSARY
NOISE POLLUTION SOLUTIONS STUDIED
CIVIL ENGINEERING IS ONE HUNDRED YEARS OLD

A LONG WINTER'S NAP

Hibernation is a good policy for bears. They avoid all sorts of problems by sleeping all winter. There's no danger of catching bearish colds, or slipping off icy logs, getting frostbite on their ears and paws, or being trapped in sleet storms.

For all practical purposes, construction workers also hibernate in the winter, and for the same general reasons. It is not easy to work in cold and snow, hampered by layers of bulky clothing. Besides the physical hardships encountered in dealing with winter, it is impossible to place concrete, lay bricks, or excavate when temperatures are below freezing.

People aren't bears, however, and winter doesn't stop them from having babies and opening businesses and moving from town to town. Although construction stops in the winter months, the need for more building goes on. In fact, if world population growth forecasts are correct, a new housing unit should be built every second starting right now to provide for the projected needs of the year 2000.

Winter construction is technically feasible. Cost is a major factor curtailing winter building activity in the United States, as are custom and tradition. Means of avoiding these difficulties have been found and are presently being put to use in Europe, Scandinavia, and Canada, where winter building is more of a necessity because of the shorter summer season.

These governments have found that continuance of building is insured through the use of government incentive and regulatory programs. The Canadian Department of Public Works has specified in its contracts that work cannot be stopped in winter without the department's permission. The Belgian government reimburses the construction firms for extra costs incurred by working on public projects through the winter. Denmark promotes year-round construction by prohibiting the start of most maintenance and repair work until October 1. Financial incentives in the form of subsidies for winter payroll costs are offered in Canada, and Austria offers loans and grants for the purchase of special tools and protective clothing.

Incentives are also offered to stimulate year-round construction in the private sector. This includes provision of subsidies toward the extra costs of winter building, technical assistance to contractors, and publicity campaigns.

Professors Clyde E. Kesler, Ronald W. Woodhead, German Gurfinkel, and Moreland Herrin of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign have proposed a research program in the area of year-round construction in the United States. They believe such a study is necessary and should be immediate, because of the extent of the demand for new construction in the near future, and the consequences if a program to fill the demand is not put into practice.

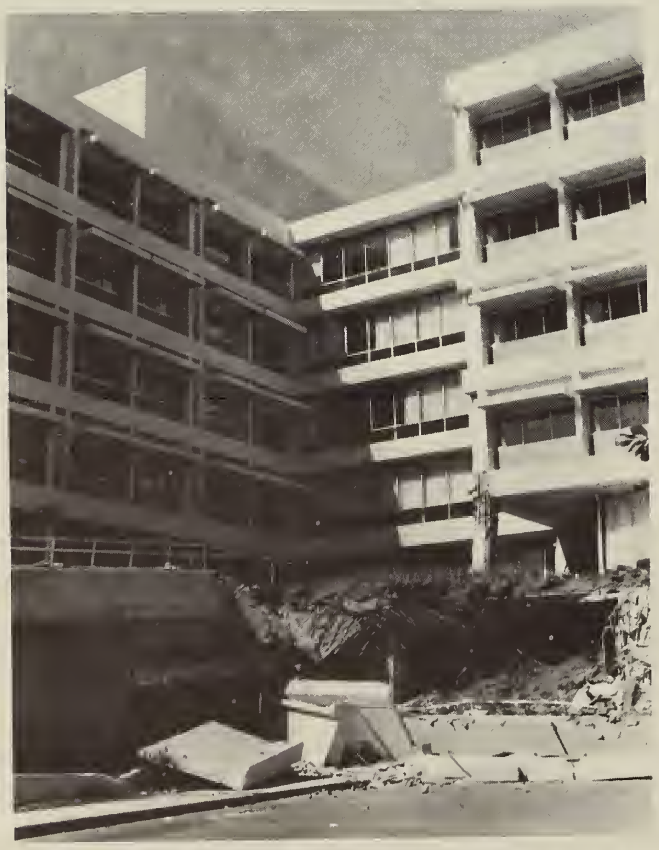
Already there is a shortage of skilled labor, and indications are that the shortage is increasing. The United States is behind many countries in making technological advances that permit year-round construction, and where advances have been made, cost is still a deterring factor. Where problems could be avoided through preplanning, winter building is hampered by institutional custom.

Professors Kesler and Woodhead see possibilities for study in the areas of scheduling, design for climatic control, education to change custom, and development of new techniques to cope with constructional problems. Specifically, the techniques under study would include prefabrication of parts, development of an efficient cold-weather concrete or of substitutions, and exploration of techniques to permit the continuation of construction operations under freezing conditions.

Their study would have implications on many levels. Unemployment would be decreased in winter, thus cutting welfare payments. The time of construction would be lessened, benefitting both the owner and the contractor. And with the assurance of enough houses for everyone, hibernation would once and for all be limited to bears. ●

WHAT'S SHAKIN'

On February 9, 1971, the Olive View Hospital in Los Angeles fell down. In addition to collapsing the roof of the $27 million hospital's day care center, the earthquake on that day took sixty-five lives and caused over $500 million damage in California's San Fernando Valley. Nevertheless, scientific instruments, previously installed in the earthquake zone to record the movements of the earth and buildings in the event of an earthquake, yielded valuable information about the physical stresses that man-made structures will have to withstand. These data are now being used to test construction techniques and materials in the hope of reducing man's vulnerability to these forces beyond his control.



Damage to the Olive View Hospital was extensive. As shown here, one part of the hospital has completely collapsed, while cracked beams are visible in other areas.

Sponsored by the National Science Foundation, investigations at the University of Illinois at Urbana-Champaign are being conducted by M. A. Sozen, D. A. W. Pecknold, N. M. Newmark, H. Aoyama, and B. I. Karlsson of the Department of Civil Engineering. In the course of these investigations, one-twelfth-scale models of portions of the Olive View Hospital are being subjected to artificially created tremors that simulate the experience of the original, ill-fated structure. On the large, horizontal platform of an earthquake simulator, the miniature frames can be made to experience a wide variety of lateral dynamic stresses to determine why the original structure fell and what can be done to prevent or reduce future damage.

Paralleling the study of the strength of the hospital frame is a study of the strength of full-size replicas of concrete beams used in the hospital building. By subjecting the beams to the effective weight of the hospital and applying lateral forces to simulate the earthquake motion, the behavior of the beams in the full-size building can be studied. Knowledge of the strength of these parts will be useful in correlating the results of tests on the model frame with the durability of actual buildings.

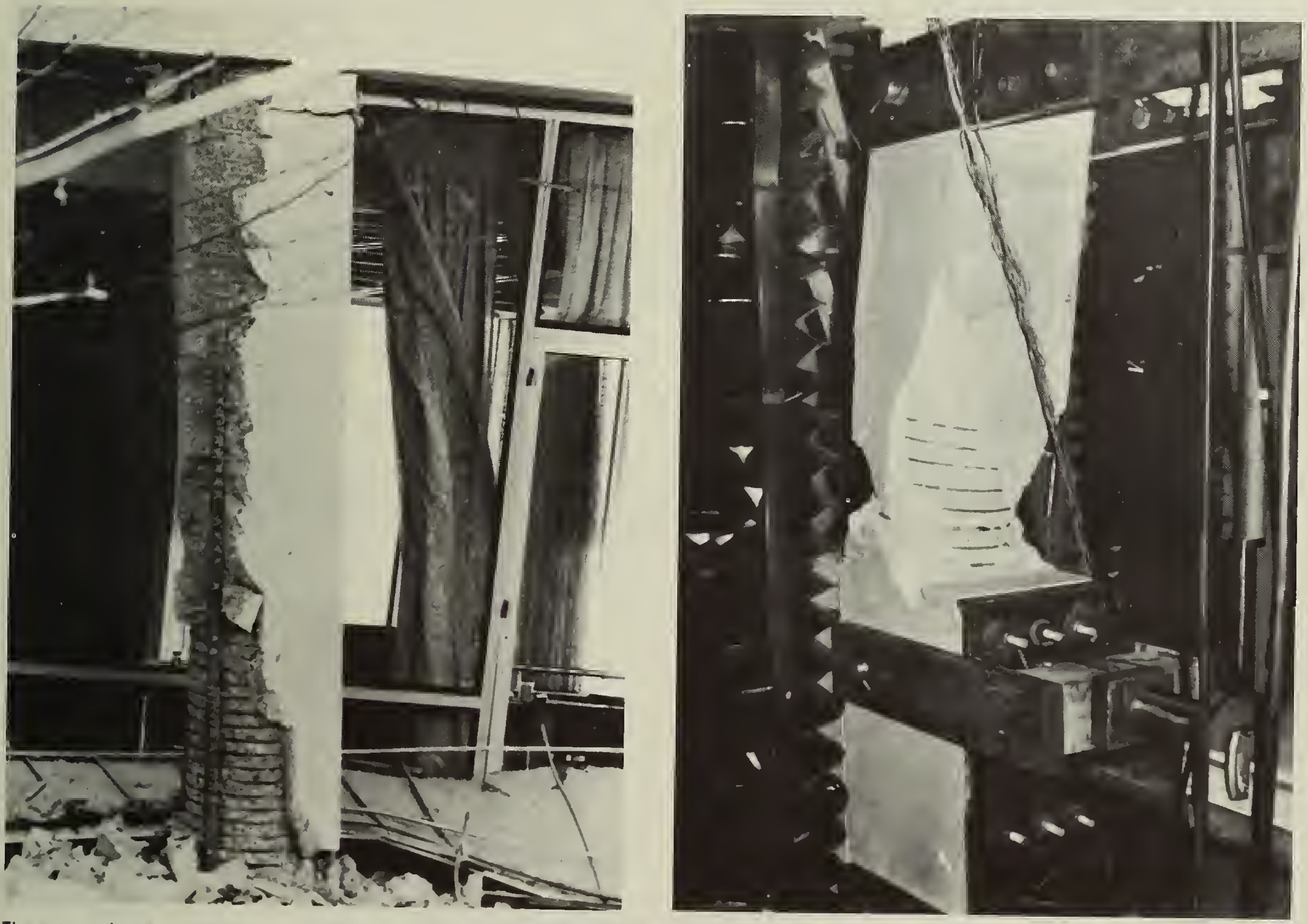
As the world's population increases, both the magnitude of the potential disasters and the need for preventative measures grow with it. Controlling earthquakes may be beyond man's capabilities, but with the outcome of this research, man's cities will be more ready for them when they happen. ●

WITH A WILL

During the years when people were staying up in the late hours of the night, headphones clamped on their ears, listening for distant radio signals, the University of Illinois at Urbana-Champaign was experimenting with crystal receivers and radio apparatus. In October of 1921 the University was granted an experimental license to operate a transmitter on 300–360 meters. The initial call letters were 9XJ. In May of the next year, the first broadcasts consisted of sports scores. The rest of the time on the air was consumed by experimental and amateur communications.

On March 28, 1922, the University was granted its first standard, as opposed to experimental, call letters in the form of a broadcast license. The new call letters were WRM, supposedly standing for We Reach Millions. The station was housed in an electrical engineering laboratory.

From 1924 to 1926, the Department of Electrical Engineering continued to try to improve the physical output of the station. They used the station to experiment with a noncontinuous carrier transmission system. By this



These two pictures compare the earthquake damage to a supporting beam of the Olive View Hospital to the results of a laboratory simulation using an identical beam. The controlled laboratory conditions allow an exact determination of the strength of the beam being tested and of the size of the forces that produced the earthquake damage. The similarity of the effect on the beam of the two different conditions is evident.

method, later patented, the carrier wave would be limited only to times when the studio microphone was actually in use. The system was designed not only to save power, but to eliminate interference between carrier waves.

Although no longer connected with electrical engineering, radio station WILL continued to prosper, and in March celebrated its fiftieth anniversary. An open house was held to help celebrate the birth of one of the first AM radio stations, commercial or noncommercial, in the country. ●

LISTEN

Listen. If your neighbor mows his lawn every morning at six, listen. If you live unbearably near an airport, listen. If jackhammers make your teeth rattle, listen. If semitrailers play leapfrog out your back door, listen.

According to a report on noise pollution by the U.S. Environmental Protection Agency, "approximately 22 million to 44 million people have lost part of the utility of their dwellings and yards to noise from traffic and aircraft on a continuous basis, and another 21 million at any one time are similarly affected by noise from construction activity." Ninety million cars, 16 million trucks, 1,200 jet aircraft, and numbers of motorcycles, lawn mowers, power tools, and construction tools contribute to the problem. If the noise levels continue to rise at the present rate of one decibel per year, by 1990 sound pressures will be 100 times greater than they are now.

Something must be done before the nation goes deaf, or suffers worse psychological and physiological damage from continuous noise.

The Noise Task Force at the University of Illinois at Urbana-Champaign may provide workable solutions to the problem of noise. The NTF, at the request of the Institute for Environmental Quality, is looking into four areas of noise pollution: noise which crosses property lines, construction noise, transportation and vehicular noise, and airport noise.

J. J. Desmond, Associate Director of the Engineering Experiment Station, is task force coordinator. Others involved in the project and their specific areas of interest are: D. H. Cooper, Associate Professor of Electrical Engineering and of Physics, and P. D. Schomer, Visiting Professor of Electrical Engineering, the makeup and causes of noise; H. W. Ades, Professor of Electrical Engineering, of Physiology and Biophysics, and of Psychology, the effects of noise on living organisms.

Also included are: A. R. Zak, Professor of Aeronautical and Astronautical Engineering, the effects of noise on man-made structures; J. J. O'Neill, Director of Speech and Hearing Clinics, the psychological effects of noise; S. J. Plager and R. W. Finley, both Professors of Law, meaningful noise regulation; and J. S. Moore, Manager, Division of Noise Pollution, State of Illinois Environmental Protection Agency, the enforcement of noise regulation.

The University has long been known as a teaching and research institution, but with the work of the task force now on its way toward making a permanent mark on the laws of Illinois, a third function of the University is becoming clear. Through the availability and quality of experts in every field of knowledge, the opportunities to use the University for public service are increasingly important. Knowledge is more meaningful if put to use, and the Noise Task Force is putting knowledge in many areas of study to use, working to benefit the public in an immediate and necessary manner. ●

CIVIL FOR 100 YEARS

The Department of Civil Engineering at the University of Illinois at Urbana-Champaign isn't afraid to tell its age. In fact the department is happy to announce the end of its successful first one hundred years and the beginning of the second hundred.

In 1872 the College of Engineering graduated six engineers, four of whom were in civil engineering. Up to this year, the College has graduated 26,700 engineers, and of this total almost one-third have been in civil engineering.

The Department of Civil Engineering has been consistently high in national ratings on the quality of its faculty. With one hundred years of experience and a nationally recognized faculty, the department is now looking ahead to the problems and challenges of the next century. ●

PEOPLE AND PLACES

Three faculty members and one student were among those receiving awards at the Engineering Honors Convocation. **George E. Anner**, Professor of Electrical Engineering, and **William W. Hay**, Professor of Civil Engineering, received the Everitt Undergraduate Teaching Excellence Award. **David A. Sommers**, senior in electrical engineering, and **George W. Eggeman**, instructor in general engineering, received the Stanley H. Pierce Award for development of student-faculty empathy and cooperation. ●

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THE LIBRARY OF THE
AUG 30 1972
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

inside outlook:

COMPUTERIZED LIBRARY SYSTEM INTRODUCED
LABORATORY FOR ATMOSPHERIC RESEARCH ANALYZES WEATHER
TWO NEW DEGREES OFFERED
ENERGY EXPENDED IN BOTTLING STUDIED
CONFIDENCE IN ENGINEERS REAFFIRMED

AND NOW, A MECHANICAL LIBRARIAN

At first it seems like an incomprehensible joke in computer language. The operator types a series of letters and numbers into the computer terminal, and in a split second the machine answers, "That's a good one." Actually, the letters have opened the circuits to a computer-operated library retrieval system now at work in the Physics Library of the University of Illinois at Urbana-Champaign.

By using this system, anyone can find information on a topic instantly without laboriously searching through printed indexes. The computer is programmed to retrieve articles by the name of the author, the subject of the article, the author's home base, the date of publication, or by any combination of index topics. It can find all the articles which give any selected article as a reference or a footnote, a process which would be nearly impossible without computer assistance. If the user knows what he wants but has difficulty describing the subject area, he may cite a representative paper on the subject. The computer then finds all of the articles which are similar in subject to the cited paper. The machine also prints out abstracts of any article stored in its memory, an important breakthrough in physics, a field where more than 30,000 articles are written each year.

James Divilbiss, Associate Professor of Library Science and Principal Research Engineer in the Coordinated Science Laboratory, supervised the development of the system. According to Divilbiss, the idea was first proposed ten years ago, but was not practical at the time; recent advances in computer technology have now made it possible. The greatest difficulty in designing the system was the necessity of translating human, nonexplicit language to a form which could be fed into a computer.

Although the computer is not able to make judgments on such subjective criteria as "interesting" or "important," it can find all the articles on specified topics through the use of key words, which describe the article's subject matter.

The present system is readily understandable, and its use is not restricted to those who can read computer printouts. The machine requests the user to enter his name on the typewriter-like keyboard and announces the commands necessary to use the machine, such as "teach," "list," and "help." It then asks politely, "What do you wish to do now?" If necessary, the computer will define all the commands, one by one, making its use as easy as reading the directions.

The information now stored in the computer covers journal articles related to physics published since January 1971. The articles are recorded on magnetic tape acquired by the University from the American Institute of Physics. The system may become part of the University's PLATO computer instructional system. Information on physics stored in the computer would then be available to users at 4,000 terminals, planned to be in operation within the next five years for an area within 150 miles of Urbana.

The success and funding of the new library system depends on its acceptance by students and faculty of the University. The time saved by the machine and the simplicity of its use should hasten this acceptance. In addition, the computer is a pleasant librarian to work with. When the user has finished working and types the command "end" into the machine the computer calls the user by name and says goodbye, without once having pointed to the "Quiet Please" sign. ●

DOING SOMETHING ABOUT IT

To find out what the weather is doing, look out a window. To find out why, look to the Laboratory for Atmospheric Research at the University of Illinois at Urbana-Champaign.

In one of the laboratory's major studies, Y. Ogura, Professor of Meteorology and director of the laboratory, is using large-scale computers to simulate small-scale weather systems. The simulation of a small system, such as a single cumulus cloud or a thunderstorm which may cover an area as small as ten miles square, involves a mathematical model of several tens of thousands of points. At each point, ten variables, such as temperature, wind pressure, water vapor concentration, and the concentration of liquid water droplets, are considered. Computer calculations can then determine how this small-scale system evolves. When more is understood about such small systems, Ogura will use the computer to simulate large-scale systems, aiding weather predictions for a much larger area.

In another project, M. S. Geller, Assistant Professor of Meteorology and of Electrical Engineering, is studying the dynamics of the upper atmosphere, where waves similar to those in the oceans are created by the gravity pull of the sun and moon and by the heating and cooling of the earth and its atmosphere. The velocity of the winds created by these waves can be measured by bouncing radio signals off ionized trails left by meteors as they pass through the upper atmosphere. Using a Doppler radar, much like the one used by state highway patrols, the wind velocity of the drifting trails is measured. These winds play a large part in determining the behavior of the ionosphere, which is important for communications and in determining reentry conditions for space vehicles.

The investigations of tropical wind circulations being carried out by R. W. Burpee, Assistant Professor of Meteorology, have given basis to the theory that disturbances leading to the hurricanes that affect North America may originate over east Africa. These studies may also help explain why some disturbances die out while others intensify to hurricane strength.

M.-K. Mak, Assistant Professor of Meteorology, is investigating the lower layer of the atmosphere, the planetary boundary layer. This is the lowest kilometer of the atmosphere, where friction between the earth and the atmosphere plays an important role. Studies such as this have an impact on the effects of pollution and the transfer of heat into the free atmosphere above the planetary boundary layer. Mak's work centers on the reactions of the weather in this layer to varying wind distributions, the effects of solar heating, and the effects of water vapor as it condenses into the liquid state.

The laboratory's research in all of these areas is especially timely since the first major research effort of the Global Atmospheric Research Program (GARP) is to take place in the next two years. GARP is a massive international research effort, coordinated through the United Nations and the International Council of Scientific Unions. Its aim is to observe the atmosphere far more completely than has ever been attempted before — by balloon soundings, satellite techniques, and aircraft and shipboard observations. The resulting information will be used with sophisticated computer models of the atmosphere to further man's knowledge of the weather.

Sophisticated techniques for observing the weather include photographs from a manned spacecraft. On the left, cumulus clouds, examples of small-scale weather systems, outline the coast of Florida. The photograph on the right shows the clouds of a major hurricane, also over Florida. These weather systems are typical of those being studied in the Laboratory for Atmospheric Research at the University of Illinois at Urbana-Champaign.

Although man has been observing the weather for thousands of years, its control is still beyond him. The advances made have resulted in part from increasingly sophisticated equipment for prediction and observation. Until control is achieved, the laboratory will continue to use sophisticated equipment, but will also keep a window open. ●

TWO DEGREES BETTER

Computer engineers specialize in the design and construction of computers. Computer scientists specialize in their operation and application. The University of Illinois at Urbana-Champaign has become the first school to offer degrees at the undergraduate level as well as at the graduate level in both of these fields.

With emphasis on different areas, the new degrees involve courses in the Department of Electrical Engineering and the Department of Computer Science. Both degrees touch upon electrical engineering and mathematics, and fill the spectrum of training and interest between the two.

The new sequences are open to both entering freshmen and to upper-level students at the University who wish to transfer into the new degree programs. ●

BOTTLING UP ENERGY

Nothing could be easier. To the consumer, *no deposit-no return* means fewer cartons of bottles taking up space and an end to maneuvering an awkward case of empties into the car and back to the supermarket.

But looking deeper into the basis of *no deposit-no return* uncovers a few hidden drawbacks. Bruce Hannon, Assistant Professor in the Department of General Engineering and in the Center for Advanced Computation at the University of Illinois at Urbana-Champaign, has made a study of the energy expended through the use of refillable versus nonrefillable bottles, and has come up with some startling conclusions.

Each gallon of soft drink sold in nonrefillable bottles requires more than four times as much energy to produce and market than each gallon of soft drink sold in refillable bottles. All the containers returned for use as raw materials in throwaway bottles require 62,000 British Thermal Units (BTUs) per gallon to produce and remelt. Refillable bottles, which are used an average of fifteen times, require only 15,125 BTUs per gallon. The energy used to manufacture, fill, and dispose of the throwaway glass and can beverage bottles in 1971 would supply all the electrical needs of Washington, D.C., for five years. Hannon also points out another, less obvious, waste of energy through the use of soft drinks. The energy a person gains by consuming the beverage is only about one-tenth of the energy expended in its manufacture. In an ideal system, the energy expended in producing a food would be returned to the person in the form of physical energy when the food is consumed.

If they are to be recycled, bottles must first be collected. The bottles shown here have been gathered by a recycling center and are about to be shipped to a glass manufacturer where the glass will be sorted, melted, and reused.

Although a switch back to the exclusive use of refillable bottles is desirable, nearly all levels of the manufacturing and marketing process have changed to accommodate the disposable container. The economic barriers to a return to refillable bottles are immense. But with the nation facing a projected energy deficit in the coming decade, the conservation and effective use of available energy becomes even more important. Professor Hannon hopes that his research will encourage the consumer to devote a little of his energy to a reconsideration of the throwaway bottle. ●

ALL WRAPPED UP AND READY TO GO

A vote of confidence by consumers for engineers and scientists has been issued through a survey of Illinois households made by a group of students from the University of Illinois at Urbana-Champaign. Working under a National Science Foundation grant, the students spent twelve weeks last summer researching a serious environmental problem: the effect of food and beverage packaging on household wastes (*Outlook,* June 1971).

Headed by Dale Jurich, a graduate student in computer science, and Richard Frederick, a senior in premedicine biology, the researchers represented eight areas of study, including civil and environmental engineering. With the cooperation of the University's Survey Research Laboratory, they collected information from a representative sample of Illinois households, based on census data.

Twenty-five percent of the consumers polled were in Chicago, twenty-five percent were in Chicago suburbs, thirty percent in the larger downstate cities, and twenty percent in the smaller communities. The students phoned and asked the cooperation of 1,500 households, sent questionnaires to 600 who offered cooperation, and received returns from 450 — seventy-five percent of those queried.

Basically, the survey revealed that consumers have fairly definite opinions on food packaging, with some variations from present practices worthy of distributor notice; that they are ecologically aware and concerned about problems of packaging and pollution; and that they have considerable faith in the ability of engineering and science to solve pollution problems.

A high percentage of the consumers polled favor nonabsorbent packaging for meat, especially the type of packaging which allows meat to be seen. Glass bottles are still the most popular form of soft drink container, and forty-three percent of the consumers polled said they would prefer returnable bottles. The suggestion of milk in plastic bags evoked little consumer interest, with plastic-coated cardboard cartons favored over other types of milk containers. In the area of processed vegetable packaging, general preference is for metal cans, with glass next, and plastic a poor third.

On attitudes about pollution, the survey indicated that forty-eight percent of the households responding feel that technology can control pollution within ten years, and forty-seven percent feel that environmentally sound packages are possible at a reasonable cost. Sixty percent agree that more federal and state legislation is necessary for successful control of pollution, and fifty-six percent feel that citizens' groups have been constructive in improving the environment. University scientists, however, were voted most qualified to help set standards for pollution control laws. Environmental education for all citizens is highly favored by the consumers polled.

With a summer of hard work behind them, the U of I students have compiled data which should be of great value to those involved with the packaging of consumer goods. Now that this project is all wrapped up, the next step is using the data to find ways of improving the environment. ●

PEOPLE AND PLACES

Ven Te Chow, Professor of Hydraulic Engineering, has been elected president of the International Water Resources Association. He will serve as president of the world-wide, nongovernmental association until 1977.

In recognition of his "concern for the growth and development of both students and professors" and "his farsighted leadership as an engineer," **William L. Everitt**, Dean Emeritus of the College of Engineering, has received an honorary doctoral degree from Southern Methodist University, Dallas, Texas. ●

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engineering outlook

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 14, NO. 1, SEPTEMBER 1972

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inside outlook:

STUDYING COMPUTERIZED COMMUNITY PLANNING
RAINFALL AND SOIL MEASURING DEVICE TESTED
REVIEW OF ELECTRONICS TO BE HELD
DISCOVERING EFFICIENT METHODS OF HEAT TRANSFER
CONTINUING EDUCATION FOR ENGINEERS PLANNED

ELECTRONIC ELECTORATE

If engineers could find a way to freeze Lake Michigan, Chicago would have a place big enough to hold a town meeting. The population would learn much about the internal affairs of its city at that imaginary meeting and would also be able to voice its opinions on the plans made to govern it.

The thought of large-scale community meetings is not so farfetched as one may think. At present the only means available for local governments to communicate with and inform the electorate is the local media. However, because of lack of time and space, the information carried on local radio, television, and newspapers is usually incomplete. In addition, the voice of the people is heard only at election time.

Due to the impracticality of freezing Lake Michigan, and the necessity for some type of two-way communications medium between people and government, a computerized town meeting is being tested. Stuart Umpleby, a graduate student in communications at the University of Illinois at Urbana-Champaign, and Valarie Lamont, a graduate student in political science at the University, with the help of a grant from the National Science Foundation, have been developing a means of using PLATO, a teaching computer, in community planning.

The PLATO system consists of terminals connected to a computer which can both send and receive messages, making PLATO a two-way communications system. Each terminal has a keyboard, a graphic display for computer-generated messages or drawings, and superimposed colored slides.

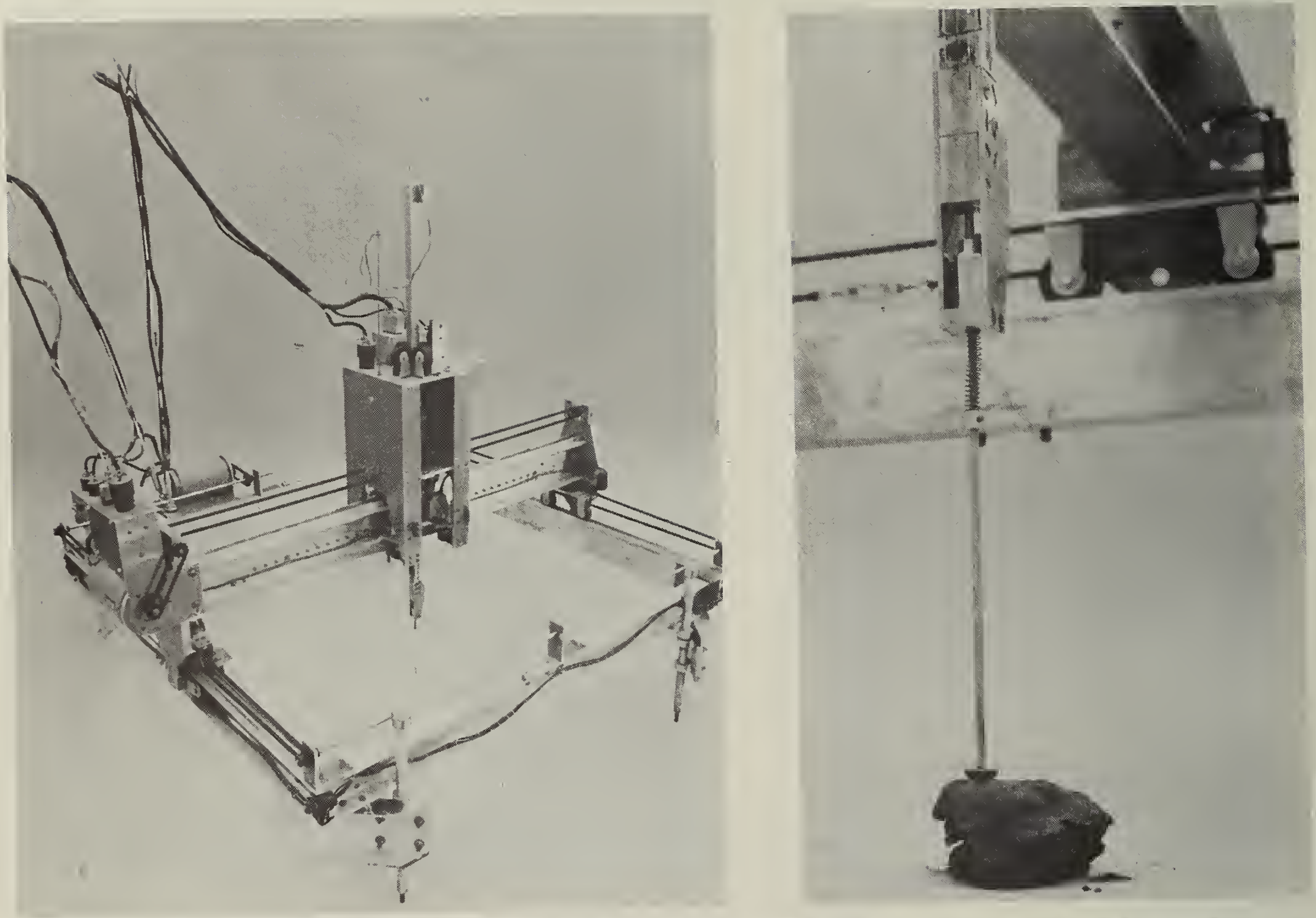
The use of PLATO seems to have more advantages than either the town meeting or mass media. With PLATO, a citizen can ask questions about an issue, learn about the issue at his own speed, and feed his own ideas and suggestions into the computer, with a guarantee that his voice will be heard.

The purpose of Umpleby's and Lamont's research is to find the most effective ways of presenting community issues through this new medium. They will also try to determine whether patterns of communication and methods of making community decisions change as a result of the availability of a new communications medium.

At this time, one method of planning has been tried, and another is being organized, to be tested in the near future. The first method allows members of the community to make choices among given alternatives. The program used to test this method, the Boneyard Creek Program, was based on a local environmental issue. Participants were given the choice between covering the Boneyard, a small creek running through the Urbana-Champaign community, and making the creek part of a park running through the two cities.

The second method involves giving participants a chance to suggest their own alternatives of action, rather than choosing between alternatives selected by a team of experts. Suggestions of topics for this type of program include local budget priorities, methods of raising revenue, and environmental issues.

As for the long-range purpose of their research, Umpleby and Lamont feel that both the frustrations of the public and the stress on public officials would be reduced if a larger part of the public was able to participate in setting goals and priorities, rather than relying only on experts and elected officials. And, Lake Michigan could remain unfrozen. ●



The profile-measuring device called Clodhopper is shown at the left. In use, a foot-deep pan of soil, which has been subject to a certain rainfall intensity, fills the yard-square frame. The probe at the right is touching the soil surface. After this measurement, it will retract and move forward another inch.

CLODHOPPER

What can measure the changes in the soil surface made by splattering raindrops? What can complete work that drives strong men cross-eyed? Only Clodhopper, the profile measuring device developed by the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign.

Clodhopper is used to determine the changes that rainfall and various tillage methods make on the contour of the soil. Clodhopper is a thirty-six-inch-square frame which is equipped with a probe that moves at one-inch intervals. The probe moves downward until it touches the soil surface. It measures the height of the soil surface at that point, retracts, and moves another inch. The information is recorded on a data recording system.

The yard-square frame yields 1,296 separate measurements. The information can be used to make a profile of the soil across the plot at any point. A profile such as this gives a visual picture of the surface of the soil before and after tillage or rainfall. The information Clodhopper records can also be used to draw a contour map of the soil within the small square plot. A map of this kind is useful in determining the amount of water storage possible on various surfaces.

Assistant Professor J. Kent Mitchell and Professor Benjamin A. Jones, Jr., both of the Department of Agricultural Engineering and developers of Clodhopper, are currently using the machine to conduct rainfall-runoff experiments. In their down-to-earth study, they are attempting to learn which types of soil and tillage combinations store the most water on the soil surface and how that storage changes after a rainfall. Runoff prevention is important because the water trapped on the surface of the soil sinks into the ground during and after rainfall, adding to the subsurface water.

Doing Clodhopper's job by hand would be tiresome and probably result in inaccurate measurements. With the help of Clodhopper and the computer, the agricultural engineers have more time to interpret their findings. In their studies of the soil surface, they can quickly get right down to the real gritty. ●

ELECTRONICS REVIEW

The Tenth Annual Review of Electronics will be presented Monday, October 16, 1972, at the University of Illinois at Urbana-Champaign. Subjects to be presented are selected from the Departments of Electrical Engineering, Physics, Chemistry, and Computer Science; the Materials Research Laboratory; and the Coordinated Science Laboratory. Individual topics to be covered include the effective control of a collection of computers, thermonuclear reactor refueling by solid hydrogen particles, and magnetic suspensions for mass transportation, to name a few.

The material will be presented at a level which is of interest to both researchers and technical management. For more information, contact Dr. Marvin Krasnow, 202 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

WRITING ON WATER

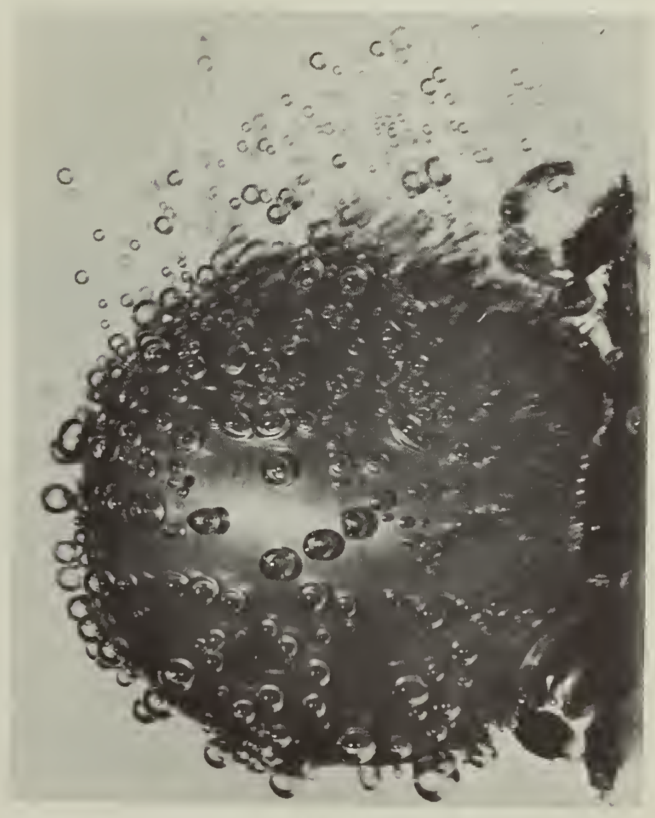
Groundwater Quality and Treatment was the title of the Fourteenth Water Quality Conference presented at the University of Illinois at Urbana-Champaign last February. Proceedings of the conference, sponsored by the University's Department of Civil Engineering in cooperation with the Division of University Extension and the Illinois Environmental Protection Agency, review and discuss current topics of interest. Papers, presented by experts in their fields, include such topics as groundwater degradation, iron and manganese removal, lime-soda softening, use of phosphates, silicates, and sequestering agents in water treatment, and groundwater quality control.

Copies of the proceedings of the Fourteenth Water Quality Conference, *Groundwater Quality and Treatment,* are available for $6.50 each from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

BOILING BUBBLES

In the laboratory of Professor James W. Westwater, it's double double boil and bubble if the rod is replaced by a turnip, and quadruple quadruple boil and bubble if the turnip is replaced by a Christmas tree. This formula has been achieved through lots of toil and trouble on Westwater's part over the last eighteen years, and deserves some explanation.

Westwater, Head of the Department of Chemical Engineering at the University of Illinois at Urbana-Champaign, is studying the mechanics of heat transfer, and more specifically, the boiling, melting, and condensation of liquids. The Macbethian formula mentioned above involves the discovery of the optimum shape for transferring heat from a surface to a liquid; in short, the most efficient method of boiling on an extended surface.



Heat transfer experiments at the University of Illinois at Urbana-Champaign are determining optimum shapes for transferring heat from a surface to a liquid. In addition to rod and turnip shapes, spheres were also tested. The sphere shown here, which is approximately the size of a thumbnail, helped to demonstrate that spheres are less efficient than other shapes in boiling liquids.

It was discovered that although immersing a rod, heated at one end, in liquid will cause that liquid to boil, the same heated surface area in the shape of a turnip will increase the efficiency of boiling by eighty percent. Efficiency is increased by 500 percent when the third shape, three disks of graduated size arranged like a Christmas tree, replaces the rod. These ideas can be used commercially in power plants and oil refineries where efficiency is of prime importance.

Through these studies Westwater has been able to predict the efficiency of various shapes produced commercially for boiling liquids. This is the first time such calculations have been made.

Another innovation introduced by Westwater is the use of photography as a research tool in the field of heat transfer. Techniques have been developed for taking motion pictures at 6,000 frames per second through a microscope with a magnification on the film of 66X. These films proved that nucleation sites for bubbles formed during boiling are microscopic pits and scratches. The common feature of these nucleation areas was found to be that each site is an excellent trap for microscopic bits of gas. Publication of these results has led to the development of commercial surfaces with artificial nucleation sites.

In recognition of his work, which has important applications in industry, Westwater has received the eleventh Max Jacob Award administered by the American Society of Mechanical Engineers and the American Institute of Chemical Engineers. This award is, of course, in addition to the satisfaction he received from dispelling once and for all the myth about watched pots. ●

OBSOLETING OBSOLESCENCE

A common practice of the hard-pressed working engineer is to guess the answer to today's problem from a solution that worked in the past. The label for this natural phenomena is obsolescence. The process of becoming technically obsolete, however, is not inevitable; there are a host of potential remedies. Perhaps the best remedy for most people is a program of continuing education.

The technical professions in the Peoria, Illinois, area are fortunate. To satisfy their need for continuing education, they can draw from the combined and complementary resources of three cooperating institutions: Bradley University, Illinois Central College, and the University of Illinois at Urbana-Champaign. These institutions are sponsoring a series of seminars to illustrate how they can serve the technical community now, and how they will be seeking collectively to serve that community in the future.

Each of the eight monthly seminar sessions, which begin in September, will devote the afternoon and evening to a presentation of topics ranging from man and his environment to management styles and effectiveness. Speakers are drawn from the sponsoring institutions, Peoria-area industry, and practicing engineers.

The sponsoring institutions hope, as a result of this interaction, that specific courses can be offered or developed, tailor-made to maintain and advance the skills of the technical practitioner. Interested persons can participate by contacting the College of Continuing Education, Bradley University, Peoria, Illinois 61606, and joining in an effort to make technical obsolescence obsolete. ●

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inside outlook:

UNDERGRADUATES INVENT A TRUCK TIRE CHANGER
SLOAN GRANT INITIATES CHANGES
BRISCOE APPOINTED TO HAER
CERAMIC ENGINEERS STUDY ENAMEL CORROSION

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HOW TO KEEP ON TRUCKING

Jerry Wagner's father owns a trucking firm. Jerry knows from experience that the only way to change a truck tire is with a wedge-back hammer and a lot of muscle. He knows, too, the amount of time it takes to demount a 40-inch, 155-pound, hard-to-handle tire. As a senior in general engineering at the University of Illinois at Urbana-Champaign, Jerry felt that this problem could be solved. With the help of Michael Clary, also a senior in general engineering, he has designed an inexpensive mechanical device for demounting truck tires.

The device uses an electric motor to power a hydraulic pump. A two-way hydraulic cylinder first forces a wedge between the bead of the tire and the rim of the wheel, and then exerts downward pressure to separate the two. Since the only current methods of doing the job are by hand or by the use of a machine costing more than $2,000, Wagner and Clary feel that there will be a demand for their small machine, which they expect to build for approximately $750.

This project, under the direction of Herbert Sprengel, Assistant Professor of General Engineering, fulfills the requirement for an engineering project design class and affords the students a chance to present their ideas to interested visitors from industry. If the favorable industrial response to the tire demounter thus far is any indication, when their plans are completed, the trucking business will be less tiresome. ●

PROGRESS REPORT

"Another major change is upon us, and it appears that scientific and engineering knowledge by itself is not enough to solve the complex environmental and urban problems facing the country. Today's engineer needs broader skills and new tools if his work is to be truly constructive. This perception is expressed increasingly by educators and students alike."

Nils Y. Wessell, president of the Alfred P. Sloan Foundation, used these words to explain the need to strengthen the social science component of engineering education. And, with financial as well as verbal support, the Sloan Foundation has presented the University of Illinois at Urbana-Champaign with a $319,000 grant to do just that in the College of Engineering.

Because of the increased need to combine engineering skill with social awareness, and to integrate this combination into university engineering curricula, the Sloan

This truck tire changer uses hydraulic pressure to force a wedge between the wheel and the rim. The tire rotates to complete the separation. This Illinois-designed changer promises to speed tire changes and lower costs.

Foundation invited twenty institutions to propose programs to accomplish such an integration. The programs proposed by the University of Illinois and seven other institutions were accepted and funded.

The two-year program at the University of Illinois will consist of a series of seminars involving faculty from engineering, social sciences, humanities, and law. The aim of these seminars is to give the participating faculty a clear understanding of the direct and indirect problems involved in the technological application of new engineering and scientific knowledge. This understanding will be a basis for developing new teaching and learning processes and will apply to the interaction of technology and the social system.

Last summer, twelve faculty members from the various participating fields planned the first series of seminars, and chose power and energy as the topic for the two-year study program. This subject is especially relevant because it involves not only the use of new technology to find new and alternative sources of energy, but also the need for society to use its present sources of energy more wisely. This deals directly with the much-discussed energy crisis: how the unwise use of petroleum and coal is depleting the finite reserves of these materials as well as damaging the environment. The energy crisis is, therefore, a societal as well as a technological problem.

The original group, aided by twelve new members, is now assembling reference materials and lecture and seminar schedules. They are also finding means of directing smaller groups working on specific areas of the power and energy problem. The program continues this fall with an expanded system of faculty seminars and training. Next spring another twelve faculty members will replace those added this fall. These teachers will bring their new ideas, methods, and philosophies to students in the classroom. Their eventual goal is to educate engineers who will be capable of planning and designing alternative technologies for the future benefit of society. They also hope to provide these future engineers with a greater capacity to communicate with people outside engineering, so that decisions about technology in the future will be to the benefit, not the detriment, of society. ●

LET'S LOOK AT THE RECORD

A long time from now, when grandfathers are telling their unbelieving grandchildren about the good old days when the Golden Gate Bridge spanned San Francisco Bay, these grandchildren will be asking, "What's the Golden Gate Bridge?" This is assuming no future catastrophe, of course, in which case they will be asking, "What's San Francisco?"

Grandfather will be able to answer questions about the Golden Gate Bridge in detail, providing he remembers the Historic American Engineering Record (HAER). HAER was begun in 1969 by the National Park Service, in cooperation with the American Society of Civil Engineers and the Library of Congress. It is a long-range program for assembling archives of significant engineering works in the United States.

Engineering structures are chosen by HAER according to their historic significance and engineering merit, with priority given to the earliest structures and those in danger of demolition. The records compiled consist of measured drawings, professional photographs, and written data on waterworks, bridges, canals, and tunnels. All information is deposited in the Library of Congress.

This summer J. W. Briscoe, Vice Chancellor for Administrative Affairs at the University of Illinois at Urbana-Champaign, was appointed to a four-year term on the Historic American Engineering Record Advisory Committee by Secretary Rogers Morton of the U.S. Department of the Interior. Briscoe has been a member of the civil engineering faculty at the University of Illinois since 1948. His appointment to HAER came after he served on the History and Heritage Committee of the American Society of Civil Engineers.

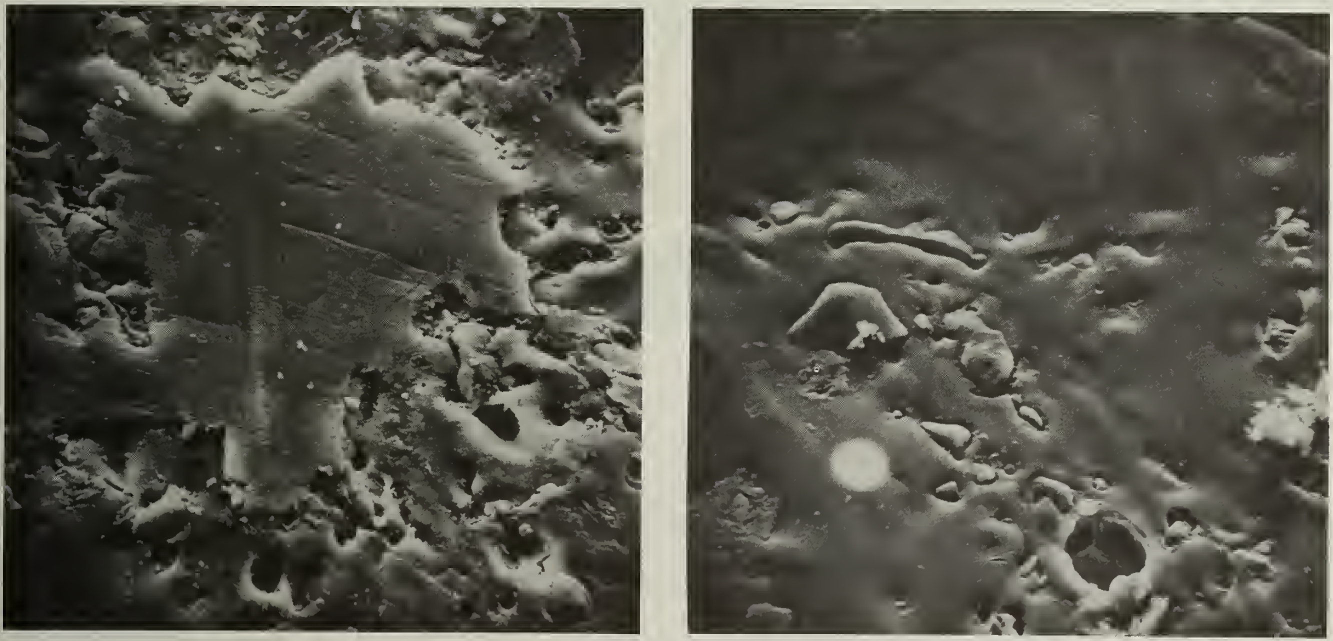
Hopefully through the work of Briscoe and the advisory committee there will be more opportunity in the future for grandfather to speak with the firm assurance of recorded history. ●

IT ALL COMES OUT IN THE WASH

Next time you visit the laundromat, instead of drinking coffee and reading out-of-date magazines, think about what is happening inside the washing machine. Not only are your clothes getting whiter and brighter, but the glass coating inside the washing machine is resisting the corrosive action of the hot water and strong detergents, as well as the abrasive action of nails, sand, and other foreign objects which may have entered the washer along with your clothing. After many years of use, the porcelain enamel (glass) coating inside the washer may begin to show wear.

One of the hardest surfaces known, porcelain enamel coatings are found in such diverse places as glass-lined farm silos, water heaters, washing appliances, kitchen ranges, cooking utensils, building exteriors, bathtubs, and beer tanks. Each application requires a different glass composition to meet the corrosive conditions encountered.

In an attempt to explain the process which causes corrosion of glass enamel coatings, Professor Clifton G. Bergeron of the Department of Ceramic Engineering at the



Strong solutions of acid or alkali react on porcelain enamel surfaces, causing an effect similar to the wear inside a washing machine after years of use. The scanning electron photomicrograph on the left shows the protective corrosion film buildup on a soft frit after exposure to a severe alkaline attack. The photomicrograph on the right shows silica grains, unmelted after firing, exposed after an alkaline attack on hard frit. Silica is one of the ingredients added to ground up frit to make porcelain enamel. The pictures show a magnification of 787X.

University of Illinois at Urbana-Champaign has been studying different types of coatings. With the assistance of Alan J. Marlor, graduate student in ceramic engineering, he is studying the effect of various corrosive agents on glass enamel through the scanning electron microscope.

Sponsoring the study is the Ingram-Richardson Company of Frankfort, Indiana, which manufactures the small particles of quenched glass, called frit, which are the main component of porcelain enamel. Enamels frequently include several types of frit. The frit is ground together with seven to ten other materials, including water, to make a mixture called slip. The slip is sprayed or painted on the metal surface and then fired. The firing process, which reaches a temperature of 1600°F and lasts only three to four minutes, fuses the enamel to the steel surface.

The two researchers found that, due to this fast firing process, the glass enamel coating does not become completely homogeneous. The different types of frit used on the enamel soften at different temperatures, causing them to be unequally distributed in the surface. Because of this unequal distribution, certain regions of the surface corrode more rapidly than others. The mechanism of corrosion can be inferred from the etch pattern when studied under a scanning electron microscope.

The microscope shows that when the enamel is exposed to a corroding agent, a thin film builds up on the enamel surface. This film protects the undersurface of the enamel until the film reaches a certain thickness. The film will ultimately fall off to expose the undersurface to more corrosive action. Another film develops, and the process continues. With enamels whose composition varies between hard and soft frits, the corrosion is unequal, causing an etch pattern.

As a result of this study, the additives to the frit, the firing process, and the makeup of the frit itself can be modified to improve the corrosion resistance of glass enamels. And laundry equipment manufacturers will be even more positive that their machinery won't fritter away. ●

A DEGREE OF DIFFERENCE

The University of Illinois at Urbana-Champaign led the nation in 1970–71 in the number of master's degrees and total degrees conferred in the combined fields of chemistry and chemical engineering, according to the American Chemical Society committee on professional training. The University also ranked second in combined doctorates and fourth in chemical engineering doctorates.

In addition, according to the professional journal *Chemtech,* more eminent chemical engineers received their initial college education at the University of Illinois than at any other institution. Of 198 chemical engineers who have received major awards, or otherwise achieved eminence, fourteen earned their bachelor's degrees at Illinois. The University is ranked fifth in the number of its doctoral graduates receiving recognition. ●

PEOPLE AND PLACES

A $1,000 Western Electric Fund award for excellence in instruction of engineering students was given to **James W. Bayne**, Professor of Mechanical Engineering and Associate Head of the Department of Mechanical and Industrial Engineering. Bayne has also been reelected to serve as vice-president of the Association of College Honor Societies.

The Boston Society of Civil Engineers has awarded **Ven Te Chow**, Professor of Hydraulic Engineering, the seventh John R. Freeman Memorial Lectureship Award. Professor Chow received the honor and a cash award at a banquet given for him in Boston.

Assistant Professor **L. Daniel Metz** of the Department of General Engineering was awarded the Ralph R. Teetor Award by the Society of Automotive Engineers for the year 1972. This award, given to about thirty educators annually, was in recognition of significant contributions in the areas of teaching, research, and community service.

The newly elected chairman of the Atomic Energy Commission's advisory committee on reactor safeguards is Professor **Chester P. Siess** of the Department of Civil Engineering. Siess has also been elected to a two-year term as vice-president of the American Concrete Institute.

Shau-Jin Chang, Associate Professor of Physics, has been awarded a two-year fellowship from the Alfred P. Sloan Foundation.

Ellis Danner, Professor of Highway Engineering in the Department of Civil Engineering at the University of Illinois at Urbana-Champaign, has been appointed Public Member of the Illinois Transportation Study Commission.

Two alumni of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign have received the department's Distinguished Alumni Award. **George L. DeMent,** Chairman of the Board of the Chicago Transit Authority until his death last March, has been honored posthumously for his career as a civil engineer in public service and his outstanding contributions to urban mass transit. Major General **Henry C. Schrader, Jr.,** the Commanding General of the U.S. Army Computer Command, Fort Belvoir, Virginia, has received the other Distinguished Alumni Award for his service to the nation as a soldier, an engineer, and an administrator of major research and development programs for the U.S. Army.

Hans Frauenfelder, Professor of Physics, has been chosen to receive a fellowship award from the John Simon Guggenheim Memorial Foundation for his work in particle physics.

John C. Chato, Professor of Mechanical Engineering and cochairman of the interdisciplinary Bioengineering Committee, has received the Distinguished Alumni Award from the University of Cincinnati. ●

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inside outlook:

NOBEL PRIZE AWARDED TO BARDEEN
STUDENTS INVENT WHEELCHAIR BRAKE
WATER QUALITY CONFERENCE TO BE HELD
AORTIC VALVES MEASURED AT UIUC

BARDEEN RECEIVES THE NOBEL PRIZE — AGAIN

The Nobel Prize for Physics has been awarded to John Bardeen, Professor of Electrical Engineering and of Physics at the University of Illinois at Urbana-Champaign. It recognizes John Bardeen, Leon Cooper, and J. Robert Schrieffer for their pioneering work on the theory of superconductivity. This is Professor Bardeen's second Nobel Prize, making him the first person in history to receive this recognition twice for work in the same field. He received his first in 1956 for the invention of the transistor.

The work on the theory of superconductivity, called the BCS theory in honor of the three men responsible for it, was done in 1957. The long lag between the research, which was all done at the University of Illinois at Urbana-Champaign, and the actual award was due to the reluctance of the Swedish academy to break precedent and make the award to the same man for a second time. With characteristic modesty, Professor Bardeen noted that he was most pleased that the award recognized his two colleagues. He had been afraid that since he had received the earlier Nobel Prize his two colleagues would not receive the recognition they deserved.

The BCS theory of superconductivity stems from the discovery made in 1911 that resistance to electrical flow in some metallic elements disappears when the elements are cooled to temperatures near absolute zero. From 1911 until the 1950s the reasons behind the phenomenon of superconductivity remained a mystery. In 1955, after years of experimentation and study on superconductivity, the BCS theory was proposed by the three researchers. It postulated that superconductivity is a condensation phenomenon. Some metals lose their electrical resistance at extremely low temperatures because the electron gas which permeates their atomic lattice condenses into a superfluid. In this liquid state the electrons are bound together into a single quantum system which extends throughout the supercooled metal. The electrons flow as a group through the metal without resistance.

The BCS theory, which won Professor Bardeen the Fritz London prize in 1962 and the National Medal of Science in 1966, opened up an entire field of study, and has been called the most important step forward in theoretical physics in the last thirty years. Practical applications of the theory include superconducting magnets of tremendous strength combined with small size and superconducting generators for more efficient generation of electrical power. The theory may even help explain neutron

stars. However, Professor Bardeen stated, "I don't think the economic impact of superconductors will be as great as the impact of the transistor. Its major effect is on science."

Professor Bardeen will share the $98,100 award with Leon Cooper, now at Brown University, and J. Robert Schreiffer, who is now at the University of Pennsylvania. He will travel to Stockholm to personally accept the award on December 17.

"This latest honor further confirms John Bardeen in his rightful place among the leading scientists of the world," said J. W. Peltason, Chancellor of the University of Illinois at Urbana-Champaign. "But even more," he continued, "all who know John Bardeen know him as the nicest, most modest, and most unassuming of scholars."

Professor Bardeen was notified of his Nobel Prize by early morning telephone calls from the foreign press. Although at first he suspected a hoax, he soon realized that he had indeed received his second Nobel Prize. ●

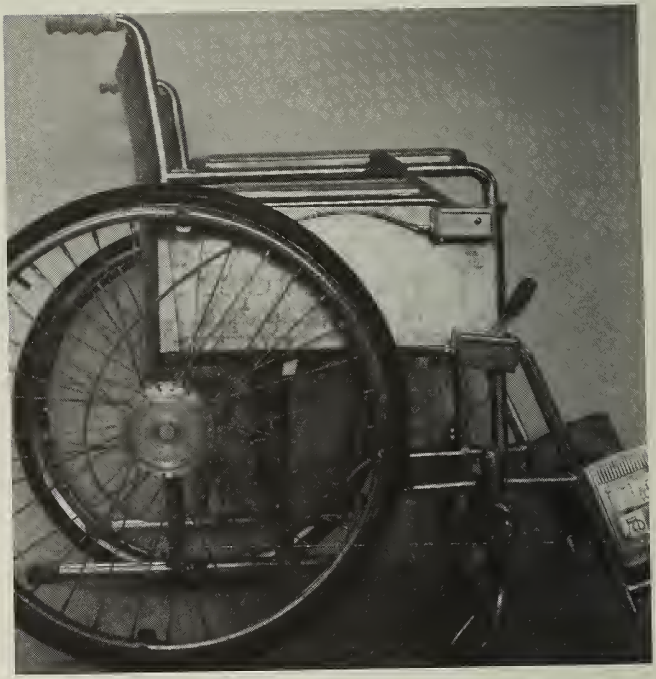
THE BIG WHEELCHAIR SLOWDOWN

People confined to wheelchairs see the world from a different point of view. Engineers don't usually share that point of view, but when the problems of wheelchair design are brought to their attention, it is the engineer who may be best equipped to solve those problems.

The problem of wheelchair brakes was brought to the attention of Jim D'Orazio, a freshman in general engineering at the University of Illinois at Urbana-Champaign, when he saw the wheels of a chair lock and throw the occupant to the ground. Questioning the necessity of this type of accident, D'Orazio studied the workings of wheelchair brakes now in commercial production.

He found that all wheelchair brakes have characteristics which limit their efficiency. There is no wheelchair braking system that will stop the chair while it is in motion. The brakes used now are mainly for holding the chair in place after it has been stopped and for preventing uncontrollable acceleration while going downhill. Another problem he discovered is that the wheelchair's braking power is inhibited when the chair is exposed to wetness or rainy weather.

D'Orazio found also that the brakes are inconvenient to use. The only way to slow down a chair traveling at a relatively high rate of speed is to grip the wheel rims. This may cause friction burns and other injuries if the hands are caught on the rim supports or on the braking system itself. Also, a sudden stop made this way can throw the occupant forward and out of the chair.



This wheelchair exhibits an experimental drum brake developed at the University of Illinois at Urbana-Champaign. The brake, located in the rear wheel, is attached to two controls. The upper control, which can be seen under the arm rest, decreases speed. The lower control holds the chair in a full stop position.

Under the advisorship of Herbert Sprengel, Assistant Professor of General Engineering, D'Orazio and two other general engineering freshmen, Scott Jeffrey and David Robbins, studied the problem. Their solution is an expanding drum brake. D'Orazio has spent his summer on the Urbana-Champaign campus trying to perfect the working model of the brake that they have assembled.

The expanding drum brake seems to correct the problems they found in other brakes. Their brake slows down the chair gradually, when going either forward or backward, and holds the chair in position at a full stop. Gradual application of braking pressure will prevent sudden stops and injured fingers. By using a drum brake in each wheel, the chair's turning ability will not be affected. Another advantage of the drum brake is that the control can be placed on the arm of the chair, keeping the occupant's hands away from the spinning wheels. It requires very little pressure to activate.

This summer the students worked on improving and perfecting their braking system. They hope to be able to market their brake when it is perfected, as the cost for the system would be less than ten dollars per chair. As it now stands, they are the first people in fifteen years to give wheelchairs a brake. ●

Editor's Note: This project, which was originally a part of General Engineering 104, a freshman design course, has won second place in undergraduate competition in the category of manufactured products from the James F. Lincoln Arc Welding Foundation. The freshmen who designed the brake were awarded $1,000, and the Department of General Engineering received $300.

WATER QUALITY CONFERENCE

The Fifteenth Water Quality Conference will be held at the University of Illinois at Urbana-Champaign on February 7 and 8, 1973. The theme is "Organic Matter in Water Supplies: Occurrence, Significance, and Control." The conference will focus on problems of organic matter in water supplies, on the effects of the health of man and aquatic life, on the standards for organic matter in water, and on the achievement of those standards.

Speakers at the conference, which is sponsored by the Department of Civil Engineering, the Illinois Environmental Protection Agency, and the American Water Works Association, include professors from various universities, researchers from private organizations, and members of the federal Environmental Protection Agency and the water treatment industry.

For more information contact V. L. Snoeyink, Assistant Professor of Sanitary Engineering, 3230 Civil Engineering Building, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

AORTA KNOW BETTER

Open heart surgery, heart transplants, man-made pacemakers — all the aspects of medical science having to do with the human heart — had to begin somewhere. At the University of Illinois at Urbana-Champaign a new dimension in saving lives through saving hearts is being added to the list. Researchers at the University are aiding in the development of a prosthetic trileaflet aortic valve.

The trileaflet aortic valve opens and closes as the heart pumps, preventing freshly oxygenated blood from backing up into the heart. The valve is composed of three parts, thus the name trileaflet. It channels the blood from the heart to the arteries of the body. When this valve is damaged by disease or injury, it does not close properly, allowing the blood to leak back into the heart, and decreasing the heart's efficiency.

Researchers in surgery and structural engineering at Washington University in St. Louis are now working on the development of a synthetic trileaflet aortic valve prosthesis which could be used to replace a damaged valve in the human body. They expect to have a usable valve ready within the next year.

The dimensions for the design and construction of the valve are being provided by the photogrammetric research laboratory of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign. This work is being done by Professor H. M. Karara of the Department of Civil Engineering, with the assistance of G. T. Marzan, graduate student in civil engineering. The molds which are being measured are provided by Washington University researchers, Dr. R. E. Clark of the Department of Surgery and Dr. P. L. Gould of the Department of Civil Engineering. Besides providing dimensions for the initial construction of the valve, one of the long-range goals of this project is to gather statistics about the relation of a person's size, weight, age, and sex to the dimensions of the aortic valve.

Although photogrammetry is usually associated with map making, it easily adapts to precise measurement of small objects. In photogrammetric measurement, two photographs of aortic valve models are measured in a stereoplotting instrument. The effect is similar to that of the old-time stereoscope. When the two photographs are taken from different angles, the eye sees the pictures as three-dimensional. The valves can be measured with high precision through this process; contour maps, profile graphs, and digital models of the sample valve molds are being compiled.

Professor H. M. Karara of the University of Illinois at Urbana-Champaign is using this top view of a trileaflet aortic valve for measurement purposes. The tiny dots visible were inserted to aid in photogrammetric measurement.

Thanks to Professor Karara's long years of experience, and to photogrammetry, the new prosthetic trileaflet aortic valve will get right to the heart of the problem, and vice versa. ●

PEOPLE AND PLACES

Stanley L. Paul, Assistant Professor of Civil Engineering, has received the 1972 T. Y. Lin Award from the American Society of Civil Engineers.

In recognition of his contributions to the invention of the transistor and for developments in the theory of superconductivity, Professor **John Bardeen** of the Departments of Physics and of Electrical Engineering was elected to membership in the National Academy of Engineering. In addition, Professor **William C. Ackermann** of the Department of Civil Engineering has been elected to the academy's sixteen-member governing council.

Professor **Ven Te Chow** of the Department of Civil Engineering is President of the International Water Resources Association, a worldwide organization concerned with all areas of water resources management and science.

Professor **William L. Hull** of the Department of Mechanical and Industrial Engineering has received the Arch T. Colwell Merit Award from the Society of Automotive Engineers for his report dealing with automobile pollution control.

The eleventh Max Jacob Award of the American Society of Mechanical Engineers and the American Institute of Chemical Engineers has been presented to Professor **James W. Westwater,** Head of the Department of Chemical Engineering.

Professor **Robert A. Jewett** of the Department of General Engineering has received the Illinois Award, the highest honor given by the Illinois Society of Professional Engineers.

The Curtis W. McGraw Research Award of the American Society for Engineering Education was presented this year to Professor **Jose B. Cruz, Jr.,** of the Coordinated Science Laboratory and the Department of Electrical Engineering, for his contributions to a basic understanding of processes underlying automation and complex engineering systems involving feedback. ●

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UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL.14, NO. 4, DECEMBER 1972

APR 3 1973
UNIVERSITY OF ILLINOIS

inside outlook:

CRIMINAL JUSTICE SYSTEMS PLANNERS AIDED
MEANS OF SAVING SOYBEANS FOUND
LIVESTOCK WASTE MANAGEMENT CONFERENCE TO BE HELD
USES FOR FLY ASH IN CONSTRUCTION FOUND

ENGINEERING CRIMINAL JUSTICE

A new approach to the problems of the criminal justice system is being made by several members of the engineering faculty at the University of Illinois at Urbana-Champaign. They are working in conjunction with the National Clearinghouse for Criminal Justice and Architecture, a planning agency of the Law Enforcement Assistance Administration, which is attached administratively to the University's Department of Architecture. Providing a multidisciplinary setting for research in the area of criminal justice system planning, the clearinghouse also establishes guidelines for correctional facilities and correctional programming for regional and community correctional facilities. Other functions of the clearinghouse include planning assistance to over 200 state and regional correctional administrations throughout the fifty states, reviewing the distribution of federal funds earmarked for correctional facility construction, and providing guidelines for court systems and police training.

Working with the clearinghouse are Professor Roland L. Ruhl of the Department of General Engineering and Professors Richard E. DeVor and Gary Hogg of the Department of Mechanical and Industrial Engineering. They are bringing their knowledge of engineering and systems analysis techniques to bear on the problems facing the criminal justice systems planner.

Professor Ruhl has recently completed a study involving computer simulation of a proposed regional correctional facility for the fifteen southernmost counties in the state of Illinois. This study represents one of the first attempts to quantitatively analyze improved efficiency in relation to the cost of construction and maintenance of correctional facilities. His simulation model of costs of the justice system, including police, lawyers, and courts as well as the cost of maintaining prisoners in a correctional institution, shows that if the proposed centralized multi-county facility were used to replace the existing system, it could pay for itself in ten years through reduction in the rate of recidivism from a typical 70 to 64 percent. That is, if the implementation of a new system could cut the number of offenders who return to crime and are apprehended after their release by only six percentage points, the money saved from this reduction would cover the cost of revamping the present system. Professors DeVor and Hogg are working on the development of a management-oriented stochastic network simulation language called GNS (Generalized Network Simulator) to aid in the simulation of large criminal justice system networks by those directly involved in prison planning. Since these planners generally do not have the computer knowledge to run efficient simulations, the development of GNS shows promise in aiding planning at the administrative level.

In addition, Professor Ruhl and Professor David O'Bryant of the Department of General Engineering are currently investigating several strategies to apply computer-assisted and computer-based education to inmate instruction. Surprisingly, the vast majority of inmates in correctional institutions have I.Q. distributions on a par with the average population, but their reading and writing skills frequently fail to exceed the fifth grade level. Professors Ruhl and O'Bryant are currently working with the Illinois Department of Corrections on a project to investigate the feasibility of providing computer-based instruction (Project PLATO) for inmate instruction at Stateville Prison in Joliet, Illinois. In addition, Professor Ruhl is investigating the application of mini-computer systems, with high-speed, hard-copy graphics input and output capability, to provide inmates with vocational training in computer-related technology. Programs for teaching computer programming, systems programming and analysis, numerical control, machine tool technology, and automated graphics are under investigation.

The work of these professors in applying engineering skills to a social problem is a big step, both in the use of computer technology to solve a human problem and in the application of knowledge available at the University to programs which will affect the country. These members of the engineering faculty can never be among those engineers accused of having no social conscience; they are putting their abilities directly to use in the service of society. ●

OVEN-ROASTED SOYBEANS

Soak regular soybeans overnight, adding soda to the water (2 tsp. to 1 qt. of water). Boil one hour in the same water. Drain. Spread in a shallow pan, and roast in 350° oven for thirty minutes or until brown. Sprinkle with salt. For added flavor, mix in melted margarine before roasting.

Although *Engineering Outlook* does not normally print helpful household hints, the recipe above does illustrate a point about soybeans. That is, they are good to eat. Most of us living in the Midwest watch soybeans being planted, being harvested, and we even occasionally joke about them, but very few of us have ever eaten any, unless they have been processed in some way. The rest of the country knows even less about them.

The main reason soybean foods have not achieved widespread popularity is their objectionable (to Americans) taste and smell. This taste and smell, which can best be described as painty or beany, has until recently been considered an inherent property of the bean itself.

It has been found that the beaniness is caused by an enzyme (lipoxidase) which develops in damaged soybeans in the presence of water. Soybeans are bruised or damaged as a result of impact from harvesting or handling. Although a means of destroying or masking the flavor from damaged beans has not been found, a way of preventing the problem has been developed by the Department of Food Science at the University of Illinois at Urbana-Champaign.

Professor E. D. Rodda of the Department of Agricultural Engineering, working with Professors M. P. Steinberg and L. S. Wei of the Department of Food Science, has developed a method of separating damaged from undamaged soybeans. It has been found that damaged soybeans swell markedly when soaked in water. By screening the beans to separate them according to size, soaking them in a solution of sodium hypochlorite and water, and then rescreening them, the damaged beans can easily be differentiated from the undamaged beans. The objectionable flavor can then be prevented by blanching whole and undamaged beans, thereby inactivating the enzyme.

Actually, soybeans contain about 40 percent protein, and are a more concentrated source of protein than red meat. They also contain almost 20 percent unsaturated fat, a source of high energy. Although soybeans have long been used as a staple food in China and Japan, they have not been widely accepted in Western cultures. Without their distinctive taste, however, they can become an easily produced and inexpensive food source in the United States. ●

LIVESTOCK WASTE MANAGEMENT CONFERENCE

Environmental quality has been added to the list of problems facing agriculture. Livestock producers must plan economical waste management systems that conform to pollution control regulations. The second annual Livestock Waste Management Conference, sponsored by the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign on March 7 and 8, 1973, will present current planning and design information.

Seasons greetings, courtesy of the Department of Computer Science.

Conference visitors will learn design requirements for liquid tanks, storage structures for solids, flushing systems, aerobic treatment systems, settling basins, holding ponds and lagoons, pumping, piping and distribution systems, and odor control. An Illinois Environmental Protection Agency representative will discuss regulations for handling livestock wastes.

For further information, including a detailed program, write Conference Coordinator, OE90, 116 Illini Hall, University of Illinois, Champaign, Illinois 61820. ●

ANOTHER OFFICE FOR THE DEAN

Daniel C. Drucker, Dean of the College of Engineering at the University of Illinois at Urbana-Champaign, has been elected president of the American Society of Mechanical Engineers. A fellow of the ASME, Dean Drucker has also served as vice-president of communications, 1969-70, and as a member of the Executive Committee Council, 1970-71.

According to the ASME journal *Mechanical Engineering*, Dean Drucker "has contributed generously to the literature and has made his expertise available to a number of engineering activities." Dean Drucker, "internationally renowned for his distinguished career in engineering mechanics," will serve as ASME president for the years 1973-74. ●

No attempt to recover fly ash is being made in the chimneys pictured here, and a valuable resource is literally going up in smoke. Researchers in the Department of Civil Engineering are working on ways to put this pollutant to use as a building material.

40,000,000 TONS AND WHAT DO YOU GET

Whether or not the Great Wall of China was a message from the Tralfamadorians, as science fiction writer Kurt Vonnegut has suggested, it nevertheless still exists. The Appian Way, too, is still usable in parts after twenty centuries of use. Whether or not Illinois interstate highway I-55 will still be usable after a few thousand years remains to be seen, but it is being built with the same material that has made the Great Wall and the Appian Way as durable as they have proven to be.

Those two ancient structures were made with a mixture of lime and volcanic ash. The modern-day counterpart of volcanic ash is fly ash, the waste product of coal-fired power plants. Approximately forty million tons of fly ash are produced annually in this country, and by 1980 the amount is expected to reach eighty million tons. Disposal of this amount of waste has been difficult. Until recently the only use made of fly ash was for landfill purposes.

In 1956 research was begun at the University of Illinois at Urbana-Champaign that put fly ash to work as a construction material. The purpose of the research is to find ways of using fly ash, which is recovered from power plant smoke stacks, and lime as a durable and inexpensive aggregate for building. Professor Ernest Barenberg of the Department of Civil Engineering is using the University of Illinois as a center for research being done in this field. By studying the ash produced by different types of coal and its reaction with lime taken from various parts of the country, it will be possible to make lime-fly ash aggregate which will greatly reduce costs by cutting down on shipping expenses. The use of locally available materials will not only cut costs, but will also put fly ash, normally a waste product, to productive use.

In the last decade, nearly fifteen million tons of lime-fly ash aggregate have been used in construction in the United States. As an example, more than two million tons were used in runways at the Newark and Kennedy airports, drastically reducing costs. Lime-fly ash aggregates develop initial strength quickly and then continue to gain strength for a long period of time. Materials have been taken from pavements in service with strengths in excess of 3,000 pounds per square inch. This continued strengthening action results in self-healing of cracks. But the mixtures are susceptible to abrasion, and therefore pavements constructed of this material are protected by a blacktop surface covering. The aggregates used in the construction of I-55 will serve as a subbase for concrete pavements rather than as a base, as in the construction of the Newark Airport.

Since it is impossible to produce nuclear power fast enough to keep up with demand, coal-burning power plants will continue to produce fly ash as a by-product for a long time. The use of fly ash for building will convert this natural material from a waste product to a natural resource. ●

PEOPLE AND PLACES

Professor **Ralph C. Hay** of the Department of Agricultural Engineering was named a Fellow of the Soil Conservation Society of America. The award, the highest honor the society confers to its members, was in recognition of Professor Hay's contributions to the science and art of good land use during the last forty years.

The International Congress of Photogrammetry has elected **H. M. Karara,** Professor of Civil Engineering, president of the Commission of Nontopographic Photogrammetry.

The **student branch of the American Society of Agricultural Engineers** at the University of Illinois at Urbana-Champaign has won first place in the annual nationwide Farm and Industrial Equipment Institute trophy competition for the fourth time in seven years.

Professor **Wendell S. Williams** of the Departments of Ceramic Engineering and Physics at the University of Illinois at Urbana-Champaign has been named to the metals and ceramics advisory committee of the Oak Ridge National Laboratories.

General Telephone and Electronics Laboratories of Northlake, Illinois, has established a $4,748 graduate fellowship in electrical engineering at the University of Illinois at Urbana-Champaign. The University of Illinois was selected for being "one of the outstanding electronics educational institutions of the nation."

A $2,110,000 grant from the National Science Foundation has replaced U.S. Department of Defense support for the **Materials Research Laboratory** at the University of Illinois at Urbana-Champaign. The grant, for the period from July 1972 through March 1974, continues funding at the annual rate previously scheduled by the Advanced Research Projects Agency of the Department of Defense.

Professor **Herman Krier** of the Department of Aeronautical and Astronautical Engineering has been given a 1972 award from the American Institute of Aeronautics and Astronautics. Professor Krier was recognized by the AIAA as one of the nation's outstanding faculty advisors for a student branch of the association. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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COLLEGE OF ENGINEERING
VOL.14, NO. 5, JANUARY 1973

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UNIVERSITY OF ILLI... IS
AT URBANA-CHAM...

inside outlook:

PROMETHEUS PROJECT FOR FUSION REACTION OUTLINED
1972 SUMMARY OF ENGINEERING RESEARCH AVAILABLE
ANNOUNCE ENGINEERING OPEN HOUSE TO BE HELD
FISHING REEL PROBLEMS UNTANGLED
WIND TUNNEL AIDS RESEARCH
UIUC TAKES HONORS AT GEAR CONVENTION

IT LOOKS LIKE GREEK

Prometheus was a Titan. Against the wishes of his father, Zeus, he stole fire from Olympus and gave it to mankind. As punishment he was chained to a rock and nibbled at by eagles until Hercules freed him.

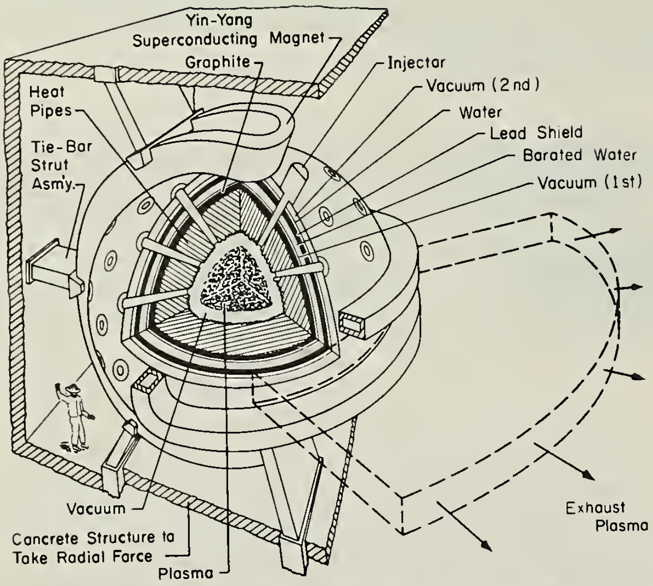
PROMETHEUS is also the name of a research project at the University of Illinois at Urbana-Champaign. It stands for Plasma Reactor Optimized for Materials Experimentation for THermonuclear Energy USage. Paraphrasing the old Prometheus story somewhat, just as the Titan benefitted mankind by bringing down fire from heaven, the PROMETHEUS project hopes to benefit mankind in the effort to provide controlled nuclear fusion. The goal of the project is to test materials and key engineering concepts required for the development of thermonuclear fusion-powered reactors. Realistic tests will be made that simulate the radiation and temperature environment anticipated in power reactors. Although a workable fusion reactor has not yet been developed, researchers the world over are approaching more and more closely to the final product.

Twenty-six staff members of the College of Engineering are involved in the project, with George H. Miley, Professor of Nuclear Engineering and Electrical Engineering, and Arthur B. Chilton, Professor of Civil Engineering and Nuclear Engineering, serving as project coordinators. Their first step in developing PROMETHEUS will be to study various conceptual designs for a small-scale fusion reactor. Since fusion, which is the combining of the nuclei of light elements to release energy, works on the same principle as the sun, they will be working with plasma having a temperature and radiation approaching that found in the sun. To confine these extremes, they will use a magnetic field. This magnetic "bottle" must involve extremely strong magnetic fields, such as those found in superconducting magnets, which demand supercold temperatures. Thus, within the experimental apparatus, the temperature of the sun and the temperature of outer space, a billion degrees Farenheit and nearly absolute zero, will exist within ten feet of one another.

The main objective of PROMETHEUS is to find out how well materials to be used in fusion power reactors will stand up under the fierce bombardment of the inner walls by the various particles coming out of the very hot plasma where the energy is produced. These particles include high-energy neutrons, fast ions, and various types of radiation. The experimental reactor will provide an environment which will permit the testing of materials under realistic conditions to see if they are suitable for power reactor use.

Although they are far from completion, the initial plans for the conceptual stage show the superconducting magnet shaped like the seam of a baseball, or, as in the diagram, like the yin yang symbol. Inside, concentric layers of materials, solids, and fluids will shield the magnet from the glowing plasma, carry away heat, and maintain a vacuum around the plasma. Researchers will be able to insert material specimens near the edge of the plasma for test purposes. They will also be able to study various means of turning the energy contained by the fusion reactor into energy which can be used to power electrical generators.

According to Professor Miley, "This apparatus is not intended to produce power. We will put in more power than comes out, but the knowledge from such research is necessary before power-producing fusion reactors can be built." The PROMETHEUS timetable calls for several years of preliminary conceptual studies, followed by three years of design studies. It is hoped that construc-



This is a schematic diagram of the plasma reactor to test materials and engineering for power-producing fusion reactors. The sketch shows mechanical and structural aspects to be developed through the PROMETHEUS project at the University of Illinois at Urbana-Champaign.

tion can start before the 1980s. "This is a big step forward," Professor Miley continued. "It shifts the emphasis from confinement studies to engineering tests, which are coupled to the broad resource of engineering talents available at the University of Illinois. Because of the encouraging work on confinement of the reaction process and the goal of commercial fusion reactors by the end of the century, the early initiation of materials studies and engineering development is an increasingly important need." ●

THE *SUMMARY* READS AGAIN

The research conducted in the College of Engineering at the University of Illinois at Urbana-Champaign for fiscal year 1972 is reported in *The Summary of Engineering Research 1972* which has recently been published. This annual publication describes the $14.4 million research program which supports over six hundred projects in the College of Engineering, including the Department of Physics, and the Department of Computer Science of the Graduate College.

The *Summary* includes project descriptions, names of sponsors and investigators, and an extensive listing of related literature.

Copies of the *Summary* are available free to students and faculty of UIUC and for a one dollar handling charge to persons outside the University. Copies may be obtained from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

IT HAPPENS EVERY SPRING

By some strange quirk of fate, it seems that St. Patrick was an engineer. This momentous discovery was made by a group of spring-fevered engineering students who needed an excuse for a holiday at the University of Missouri in 1903. Conveniently, St. Patrick's Day fell at the time, between semester break and Easter, when hard-working students felt the need for a celebration.

At the University of Illinois at Urbana-Champaign this year, the patron saint of engineering will be commemorated on his day by the Engineering Open House (EOH). This event, held annually for the last sixty years, is planned and carried out primarily by students and attracts thousands of visitors each year.

Friday, March 16, and Saturday, March 17, are the dates for EOH '73. With the theme, "Engineering Makes a World of Difference," students and faculty will show that engineering does play a significant and varied role in today's world. The EOH, a time-honored way to demonstrate innovations, is open to all who wish to attend. For more information, contact Ron Elliott, 300 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

THE REEL THING

Professor C. S. Larson of the Department of Mechanical and Industrial Engineering leaves Illinois each year to fish in Canada. Since his approach to fishing is a bit more elaborate than the bent pin and worm technique, and his time is limited, he likes to see things run as smoothly as possible. This includes, of course, the run of the line off his reel.

Combining business with pleasure, Professor Larson cast his mind on the snags he found in his reel. With help from graduate student Frank Topel and with parts supplied by a Minnesota reel manufacturer, along with discussions with the manufacturer's chief engineer, Professor Larson took high-speed movies of the reel in action to determine the dynamic characteristics of the line. The difficulties identified included snagging of the line on the main spindle and the inherent noise problems due to the gear transmission. An investigation of the gear profile was made and some suggestions were offered to reduce the undesirable noise through muffling the closed faced portion of the reel.

Officials of the reel manufacturing company have incorporated some of the ideas developed by this investigation, and problems with the reel have abaited. By striking on the right combination of improvements, Professor Larson has taken the catch out of fishing. ●

WHERE THERE'S SMOKE, THERE'S RESEARCH

At one end of an eighteen-foot wind tunnel on the UIUC campus is a miniature replica of a geographical area one mile in diameter. In the center of this replica is a tiny smokestack, pouring smoke over a miniature town. Although with all this detail one might expect to see an accompanying electric train complete with depot and station master, the scale model actually permits study of exactly where the smoke from the smokestack goes under varying wind speeds and directions.

The Department of Aeronautical and Astronautical Engineering at the University of Illinois at Urbana-Champaign has added an eighteen-foot test section to an existing wind tunnel to study phenomena in the atmospheric boundary layer. The tunnel, the only one of its type in an Illinois university, is driven by a large fan that provides wind speeds from five to fifty miles an hour blowing over the scale models of buildings, cities, and countryside. The project that sparked the development of this facility involved the study of smoke plume dispersal in the vicinity of a large factory. For this purpose, the geographic replica was built.

The project was started originally at the suggestion of the Division of Air Pollution of the Illinois Environmental Protection Agency. The Agency needed more information to make a decision as to whether or not to allow a factory near Depue, Illinois, to continue operation. The factory was supposedly pouring smoke over the town of Depue. The smoke was not only offensive, but was also corroding paint on houses, cars, and other materials. To gather more information which would enable them to make an educated decision, the EPA partially funded the wind tunnel. The experiment, headed by K. R. Sivier, Professor of Aeronautical and Astronautical Engineering, showed that the two-hundred-foot smokestack was affected by a bluff, also about two hundred feet high, on the north. Especially interesting was the discovery that a gully northwest of the factory and in direct line with the smokestack caused the smoke to sink rather than rise by the interaction of gully-formed wind currents and the height of the smokestack.

Synthetic fog is used to simulate smoke in this scale model of an Illinois community. This photograph is one of many used by UIUC engineers to study the effects of wind speeds and directions on smoke plume dispersal.

The wind tunnel also can be used to study the effects of wind pressure distributions on buildings, and, by suitable cooling of the air near the surface, to simulate the temperature inversion situation. Temperature inversion tends to prevent smokestack gases from rising, trapping them close to ground level.

Until an effective means of filtering all smoke so it ceases to be a problem is found, the effects of temperature and wind currents on smoke plume dispersal will generate study. What was said in 1880 can be said even more appropriately in these days of concern about environmental pollution, "You can hide the fire, but what are you going to do about the smoke?" ●

ILLINOIS PUTS TEETH IN GEAR CONFERENCE

The International Symposium on Gearing and Transmissions, "the most significant gear conference ever held on this continent," took place in San Francisco last October. Over seventy papers were presented by representatives from seventeen different countries. Significant to the College of Engineering at the University of Illinois at Urbana-Champaign was, that out of twenty-seven papers presented by representatives of the United States, six of these were presented by seven persons who are members of the UIUC Departments of Mechanical and Industrial Engineering and of General Engineering or who were graduated from them. Nine persons who are present or previous members of the staff of the College of Engineering represented the UIUC as authors, chairmen, or vice-chairmen. Of these nine, one was Professor E. I. Radzimovsky of the Department of Mechanical and Industrial Engineering, and another six were present or former students of Professor Radzimovsky. ●

PEOPLE AND PLACES

H. M. Karara, Professor of Civil Engineering, has been elected to the Technical Commission in the International Society of Photogrammetry.

Mete A. Sozen, Professor of Civil Engineering, and **N. N. Nielsen**, former faculty member, shared the Leon S. Moisseiff Award of the American Society of Civil Engineers for their paper, "Reinforced Concrete Response to Simulated Earthquakes."

Emmett F. Kraus, graduate student in aeronautical and astronautical engineering, has won first place in the annual student paper competition of the Human Factors

Society, an international professional organization interested in the design and operation of man-machine systems. This is the second consecutive year a graduate student from UIUC has won this prize.

Professor **Nathan M. Newmark**, head of the Department of Civil Engineering, has been awarded the degree of Honorary Researcher by the National Laboratory of Civil Engineering of Portugal. Eleven distinguished civil engineers from six nations were honored as the first presentation of this degree was made on the occasion of the laboratory's twenty-fifth anniversary.

Professor **Nick Holonyak, Jr.**, of the Department of Electrical Engineering, has been appointed to the electronic technology evaluation panel of the U.S. National Bureau of Standards Institute for Applied Technology.

Dean **Daniel C. Drucker** of the College of Engineering has been elected treasurer of the International Union of Theoretical and Applied Mechanics. He is the second American to hold office in IUTAM since its founding in 1946.

Professor **Clarence Coates, Jr.**, Director of the Coordinated Science Laboratory, is one of four new appointees to the Science Information Council, advisory group to the National Science Foundation Office of Science Information Service.

Professor **Benjamin A. Jones, Jr.**, of the Department of Agricultural Engineering, has been advanced to the grade of senior member in the American Society of Agricultural Engineers. Professor Jones has served the ASAE since 1955 on national committees including the Board of Directors.

Harry G. Drickamer, Professor of Chemical Engineering and of Physical Chemistry, has received the William H. Walker Award of the American Institute of Chemical Engineers.

Ven Te Chow, Professor of Hydraulic Engineering in the Department of Civil Engineering, has been elected president of the Hydrology Section of the American Geophysical Union. His term will run from 1974 to 1976.

Professor **Jose B. Cruz, Jr.**, of the Department of Electrical Engineering and the Coordinated Science Laboratory, has been named for the 1972 Curtis W. McGraw Research Award of the American Society for Engineering Education. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL.14, NO. 6, FEBRUARY 1973

APR 3 1973
UNIVERSITY OF ILLINOIS

inside outlook:

HOLONYAK RECEIVES LEIBMANN AWARD
AUTOMATIC DAIRY FEEDING SYSTEMS DEVELOPED
PROPERTIES OF CERAMIC BONES REVIEWED
1973 BUSINESS-INDUSTRY FORUM TO BE HELD

LET THERE BE DIODES

What do you give someone who has constructed the first semiconductor laser to operate in the visible spectrum, who has contributed to the development of four- and five-layer semiconductor control devices, and who has studied stimulated emission from nitrogen-trap transitions in semiconductor alloys? You give him the 1973 Morris N. Leibmann Award of the Institute of Electrical and Electronics Engineers, of course. In February, at the International Solid State Circuits Conference, Professor Nick Holonyak, Jr., of the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign will receive that award "for outstanding contributions to the field of visible-light-emitting diodes and lasers."

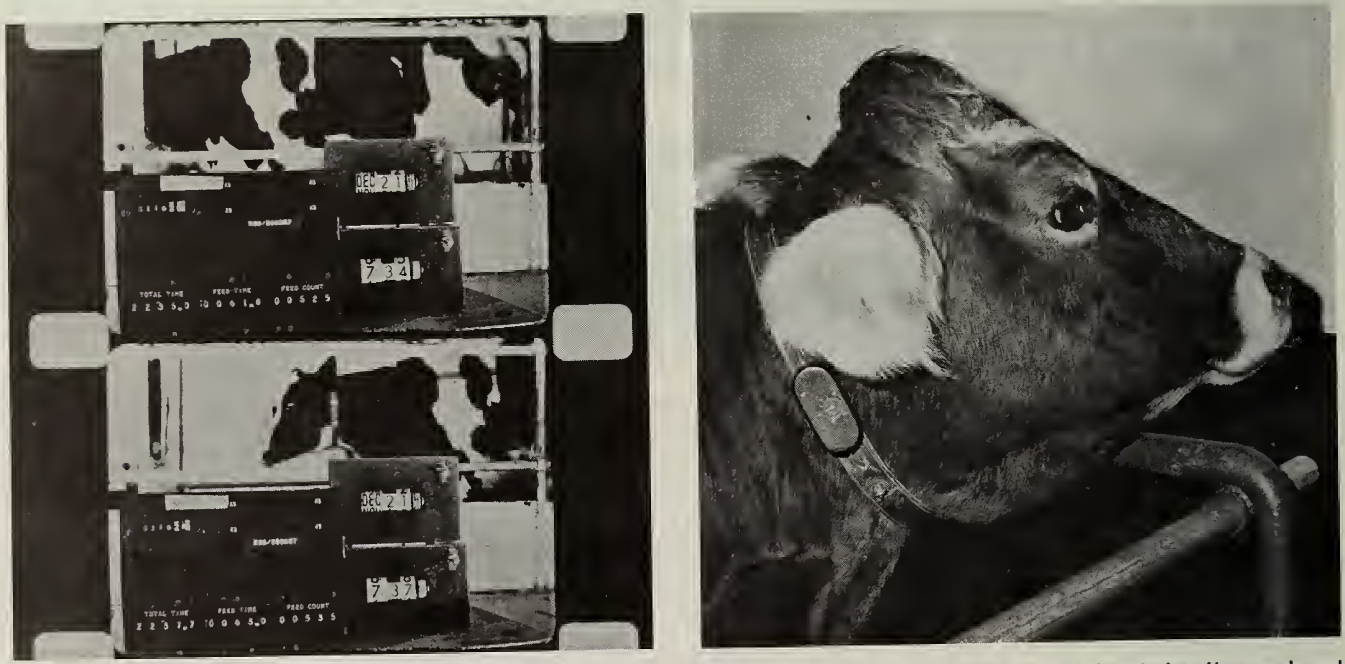
In 1962, while working for the General Electric Company, Professor Holonyak fabricated the first visible semiconductor laser out of gallium arsenide phosphide (GaAsP), the same material used in the currently most widely used but less sophisticated light-emitting diode, one of the most important recent innovations in the visual display of information. In fact, he first (1960) made a p-n junction in GaAsP, and then made it into a laser (1962) by building it a bit differently.

Take an ordinary light bulb, a fluorescent lamp, a gas-filled glow lamp, or a cathode-ray tube outside and drop it on the sidewalk. Then try to use it. Find out what it costs to make a light bulb small enough to fit on the tip of a pencil, and then think about using enough of them to create the effect of a theater marquee in miniature. Finally, figure the time and trouble when an essential indicator lamp on a piece of equipment burns out. The only alternative is a light-emitting diode. They are as rugged and reliable as the integrated circuits and transistors with which they are used, require very little power, and may not burn out for a hundred years. With these facts in mind, the significance of their development may be a little clearer.

During earlier work for the General Electric Company, Professor Holonyak was involved in the development of four- and five-layer semiconductor devices, including the special version used in household light dimmers. Certain of these devices are small enough to fit, together with an entire circuit, in the handle of an electric drill, yet provide continuous control over its speed. They fit also in the space occupied by a household light switch and give continuous control over the brightness of the light. Without moving parts, these devices can be used to switch large amounts of power as does a relay, or to control the precise amounts of power delivered to any appliance, such as the light or a drill.

On the faculty of the University of Illinois at Urbana-Champaign since 1963, Professor Holonyak and his students were the first to achieve laser operation in three other visible-spectrum semiconductor compounds besides the GaAsP compound. Presently work is being done on increasing the efficiency of the GaAsP compound through the addition of nitrogen atoms, in order to increase the diode's efficiency in color regions beyond the low-frequency, hard-to-see reds.

Light-emitting diodes are being used more and more frequently for commercial purposes in pocket-size computers, clocks which use figure display panels instead of dials, and perhaps soon in automobile dashboards, where lighted numbers will replace temperature, fuel, and speed gauges. Much of this is due to the pioneering work of Professor Holonyak. ●



The neck transponder unit on this cow's collar regulates the amount of feed she will receive from the automatic feeding device. How much and when she actually eats is recorded by the data-record film shown on the left. This device was developed by the UIUC Department of Agricultural Engineering to show the date, time, and amount of food dispensed at each feeding.

HOLY SMOKE

The December 1972 *Outlook* featured a photograph of two factory smokestacks and used them as an illustration of fly ash "going up in smoke." Information has since been received pointing out that in actuality the reverse is true, a fact that could have been deduced from the whiteness of the smoke. The company, located in Chicago, had electrostatic precipitators installed when the stacks were built in 1961, with efficiencies of 98 percent. Last year alone over 7,000 tons of fly ash were recovered from those stacks — fly ash used both for landfill and as aggregate for making concrete. And so, as a result of at least one company's concern for the by-products of their operation, the beauty of an unpolluted sky, and not fly ash, is in the eye of the beholder. ●

THE CORN IN THE COWS

A blast of little boy blue's horn will get the cows out of the corn, but getting the corn into the cows is not quite that easy. Dairy cattle must be fed, as well as milked, every day, seven days a week. To complicate matters, their feed should be in proportion to the amount of milk they are giving, an amount which changes week by week. Extra time is involved also in postfeed cleaning. These jobs add up to a tremendous number of man-hours and become costly to the dairy farmer.

An interdisciplinary study group at the University of Illinois at Urbana-Champaign has been working since 1959 to reduce the amount of man-hours necessary in dairy cattle feeding. The joint efforts of Professor E. F. Olver of the Department of Agricultural Engineering, Professor K. E. Harshbarger of the Department of Dairy Science, Professor H. B. Puckett of the Department of Agricultural Engineering and the U.S.D.A., and G. M. Hyde, also of the Department of Agricultural Engineering and the U.S.D.A., have provided two methods of feeding dairy cattle automatically.

One method feeds cows in production groups of twenty to thirty-six. Arranged in five groups, the cows receive grain-forage rations according to production group. This arrangement eliminates the necessity for individual attention yet increases feeding accuracy. Central to this system is the control panel which rations feed by weight from five different silos and moves the feed by conveyor to the feedlots. In this manner feed can be delivered as often as fourteen times a day or as seldom as once a day.

The other method developed by the UIUC researchers works on the principle that, although forage can be fed by the free-choice method, the amount of high-energy concentrates must be individually controlled to obtain the most economic level of intake. The automatic feeder they developed represents an interesting combination of technology and common sense.

Each cow wears around her neck a tiny radio transmitter which activates a concentrate dispenser when she enters the special feed stall. When she has eaten her quota of concentrate, a memory device stops the flow of feed into her bowl. An automatic camera records the time of day and amount eaten when she enters and leaves the feed stall.

Tests have shown that cows fed automatically produce as well as those fed by hand. Mechanization of feeding can increase the amount of milk produced per dairy worker and decrease costs. Full automation of dairy farming is an impossibility, because cows will never learn to milk themselves. Self-feeding, however, is a step in the right direction. ●

A CURE FOR CONCRETE

A new bulletin in the Engineering Experiment Station series recommends that concrete should be dried for three days after seven days of moist curing for improved resistance to freezing and thawing. The bulletin, the final report of research performed by the UIUC Department of Civil Engineering in cooperation with several state and federal agencies, is *The Effect of Drying on the Freeze-Thaw Durability of Concrete,* by A. Y. C. Wong, C. L. Anderson, and H. K. Hilsdorf. Copies of Bulletin 506 are available at $5.00 per copy from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

NO BONES ABOUT IT

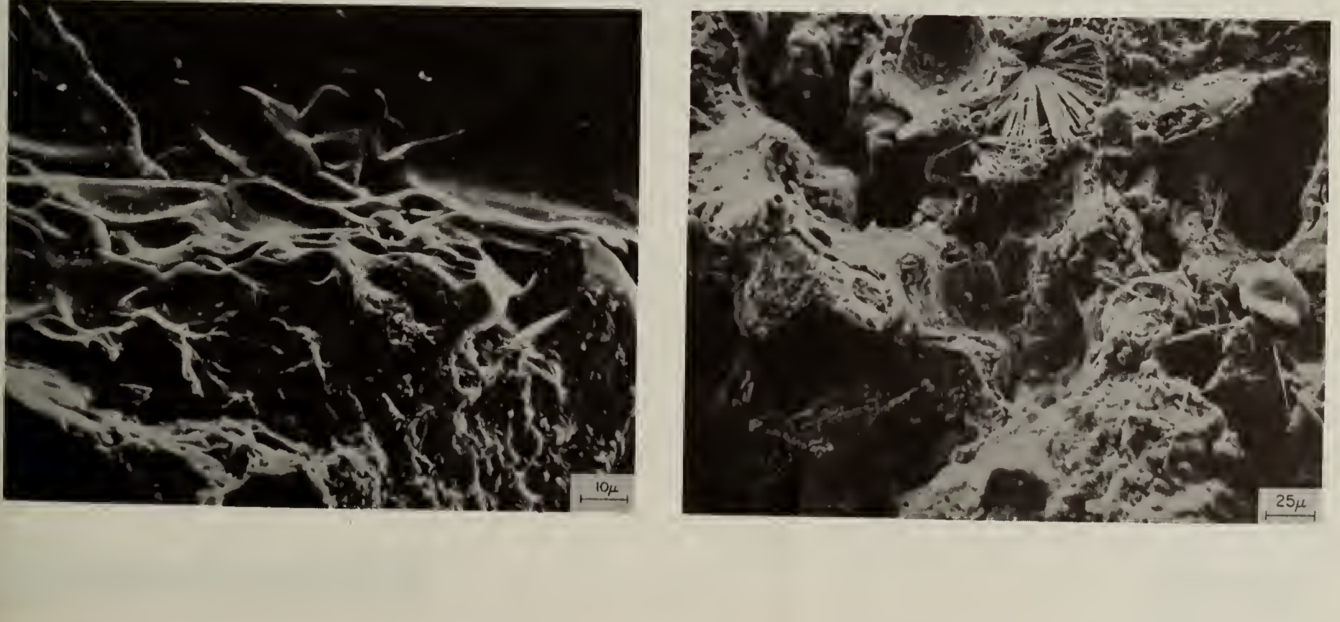
The first man-made ceramic used to replace damaged bones in the body, reported in the 1930s, was plaster of Paris. As orthopedic prostheses, however, plaster of Paris had one major drawback — it dissolved. It was not strong enough to bear weight, and it soon broke down in the body. Today a parallel situation is seen with orthopedic ceramics, and it's back to the drawing board again. According to research recently conducted at UIUC, orthopedic ceramics, hailed with enthusiasm a few years ago, also have their drawbacks.

The materials tested were calcium aluminate and alumina. They proved successful in tests for biological compatibility and short-term strength. Making these materials especially convenient was their receptivity to the ingrowth and attachment of bone and tissue in their porous or notched forms. The lack of ability to form attachments had been one of the biggest problems with metals used to repair bones.

Professors S. D. Brown and G. H. Kenner of the Department of Ceramic Engineering believed the claims of success with these materials were somewhat premature. They recognized that the area of reaction of the material within the biological environment over time had not been fully investigated and conducted their own tests of the materials' reaction to aging and fatigue *in vivo* and *in vitro.*

Their tests showed that both calcium aluminate and alumina lost strength when aged either *in vivo* or *in vitro.* As expected, the losses seen with alumina were not as severe as those with calcium aluminate, which showed severe microstructural changes when examined with a scanning electron microscope. More encouraging were the results of their studies with biologically compatible glassy carbon, which showed good ability to resist attack by the body.

According to the two professors, more basic research must be done to develop a ceramic material which can resist the attack of body fluids and at the same time retain the other attributes of ingrowth and attachment. This is especially important because the very properties which



The electron microphotograph on the left shows the crack surface of an unaged calcium aluminate bar. On the right, the same bar has been aged for three months in a biological environment and exhibits cracks and hydration crystals. Calcium aluminate is one of the materials being tested in the UIUC Department of Ceramic Engineering for use as prosthetic bones.

make ceramics better for use in the body also make them more difficult to replace if cracked or damaged. The tests have shown that under conditions of use, the likelihood of damage is high.

A quick survey of Brown's and Kenner's results indicates that, if you have a bone to pick, you may not want to pick these — at least not yet. ●

LAW OF THE LAND

Legislation designed to save the country's land, air, and water carries with it problems for industry, whose job it is to implement that legislation. The problem will be studied at the 1973 Business-Industry Forum, to be held at the University of Illinois at Urbana-Champaign on April 5 and 6. Attorneys, industry spokesmen, insurance specialists, federal administrators, and academicians will address themselves to the theme, "The New Concepts of Justice — Can Industry and Business Survive?" Speakers will include retired justice of the United States Supreme Court Thomas Clark and John E. Corbally Jr., President of the University of Illinois. The forum is sponsored by the UIUC Colleges of Commerce and Business Administration, Law, and Engineering, and the Alumni Association. Further information can be obtained from Professor R. Strout, 148 Mechanical Engineering Building, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

Ross J. Martin, Associate Dean of the College of Engineering and Director of the Engineering Experiment Station at UIUC, is chairman of the committee planning the fourteenth annual Argonne Universities Association-Argonne National Laboratory Nuclear Engineering Conference for March 5 and 6.

Kung C. Yeh, Professor of Electrical Engineering, has been elected fellow of the Institute of Electrical and Electronics Engineers. He is the seventeenth UIUC faculty member to be elected.

Ellis P. Danner, Professor of Highway and Traffic Engineering, has been appointed to a two-year term on the Illinois Transportation Study Commission.

B. B. Ewing, Professor of Civil Engineering and of Nuclear Engineering, has been named Director of the Institute for Environmental Studies at UIUC. He has been acting director since the institute was organized.

The ASHRAE E. K. Campbell Award of Merit was presented to **Wilbert F. Stoecker**, Professor of Mechanical Engineering, for "outstanding service and achievement in teaching."

Seichi Konzo, Professor Emeritus of Mechanical Engineering, has received the F. Paul Anderson Gold Medal, the highest award of the ASHRAE, for "great contributions to the education of students and to knowledge valued by the industry." Professor Konzo came to UIUC in 1927 and retired in 1971. ●

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inside outlook:

RURAL INTERSECTION ILLUMINATION CRITERIA
PREVENTIVE MEASURES AGAINST COAL MINE EXPLOSIONS
SYSTEMS ANALYSIS OF CLIMATE CHANGE
FEASIBILITY STUDY FOR ELECTROSTATIC FACSIMILE MACHINE
AERODYNAMIC MOMENTS OF SHINGLES
TEST OF DRIVER QUALIFYING EXAMINATIONS

THE LIGHTER SIDE OF CROSSROADS

Coming across a lighted rural intersection at night may or may not be an illuminating experience, according to a recent study completed in the UIUC Department of Civil Engineering. In other words, taking a long drive down a country road at night can be dangerous, especially at intersections. One-quarter of all rural motor vehicle accidents occur at intersections, although intersections account for only a small part of highway miles.

Illumination of the intersection is an often used method of reducing the risk of night-time rural driving. However, whether or not illumination is the answer for all intersections, and how much the accident rate is actually reduced when lighting is installed, had never been measured. Professors Robert Wortman of the University of Illinois and Martin Lipinski, now with the University of South Carolina, have completed a study that gives criteria for determining when the benefits of illumination are worth the cost of installation.

Data from the Illinois Department of Transportation provided information on traffic volume, accident characteristics, and lighting for over 100 intersections. The resulting data enabled the professors to outline a method that could be used by highway planning engineers for ranking or selecting intersections for lighting treatment. This quantitative method of selecting areas for lighting will result in more efficient use of the highway tax dollar, and will also give motorist safety a larger role in intersection improvements. ●

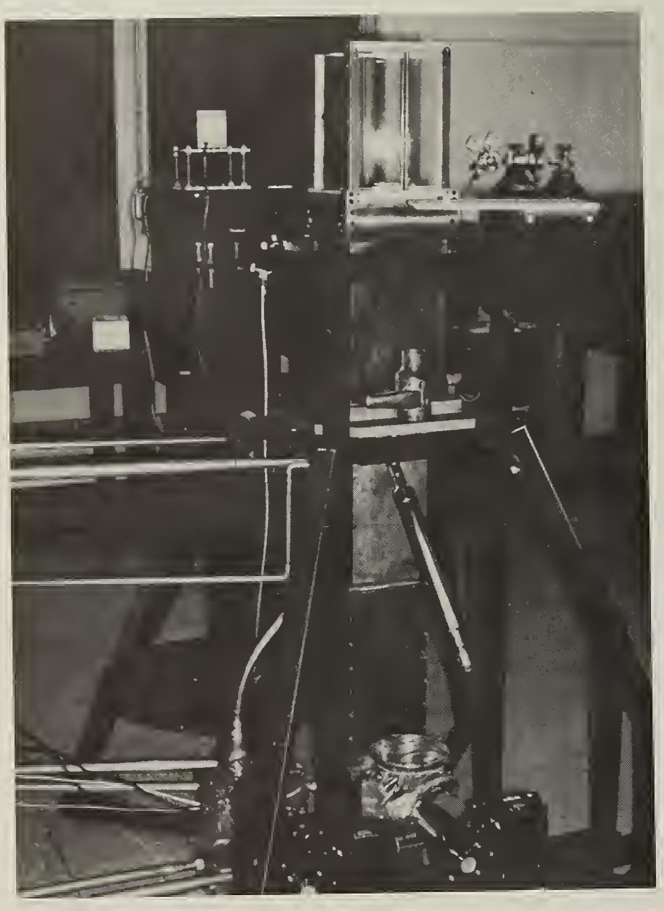
PREVENTING MINER DIFFICULTIES

Methane gas is an ever-present part of coal mining. The spark created by a shovel striking rock can easily ignite the methane, triggering a small explosion. When the explosion is larger, the resulting turbulence picks coal dust from the floor and walls of the mine shaft. The combination of air, methane, and coal dust, all of which are relatively harmless alone, causes a chain reaction which can carry the explosion through miles of mine shafts.

A method of protecting lives and property from this kind of explosion is being sought in research at UIUC sponsored by the U.S. Bureau of Mines. Proposed is a device, to be installed thirty yards from the working face of the mine, that would sense an approaching flame and quench it with a nontoxic gas or chemical before the mounting explosion spreads out of control.

To learn basic facts about methane and coal-dust burning, and to learn how various gases and chemicals affect them, Professors Roger Strehlow and Herman Krier of the Department of Aeronautical and Astronautical Engineering and Lester Savage and Spencer Sorenson of the Department of Mechanical and Industrial Engineering have built a laboratory-scale burner to simulate conditions in the mine.

The burner is only six and one-half by four inches in area. Nitrogen flows from the burner on two sides to shield it from the air. A two- by three-inch rectangle in the center of the burner serves to inject a mixture of air, methane and/or coal dust, and the extinguishing material. This is surrounded by a layer of pure air plus methane and/or coal dust which is burning on the outer rectangle of the burner. The entire burner is surrounded by an open-top glass box, through which the flame can be photographed. Strehlow and his associates can determine the effects of different materials on the methane-coal dust flame by measuring the angle at which the inner flame attaches itself in the flow. This gives them an accurate measure



UIUC aeronautical engineers have developed this burner to explore means of quenching coal-mine explosions. The behavior of methane, nitrogen, coal dust, and extinguishing materials can be recorded through the glass case surrounding the flame at the top.

of flammability limits and will therefore enable them to examine the relative efficiency of different extinguishing compounds.

This work is unique in its field. Prior research on flammability properties has been for the most part performed in small static apparatus and is quite dependent upon testing conditions. The data obtained from this study will be generally applicable to all burning conditions, making it easy to apply knowledge derived from the simple simulation to actual mine conditions.

The material that will be used in the activation of the proposed sensing device must quench flames from methane, from coal dust, and from various combinations of the two with air. In addition, it must be effective at low concentrations and nonpoisonous to the miners who will be exposed to it. To find the best compounds to satisfy all these criteria, many hours of experimentation will be necessary, and results are not expected before next fall. If the researchers do succeed, however, future coal mine explosions may go off, not with a bang, but a whisper. ●

SOME LIKE IT HOT, SOME DO NOT

As far as climate is concerned, the world seems to have a choice of which way to go. Some like it cold and prefer the particulate dust hypothesis in which the earth will be blanketed by suspended dust particles, a result of smoke emissions. The radiant warmth from the sun will be reflected before it reaches earth. This will cool the earth, causing large ice covers which also reflect rather than absorb sunlight and in turn cause more ice.

But, some like it hot and are proponents of the greenhouse effect. They feel that the increased carbon dioxide discharge into the atmosphere resulting from the use of fossil fuels also changes the radiation balance properties of the atmosphere, making it more heat absorbent. Carried to its logical conclusion, this theory implies that the world will cook itself.

It is difficult for scientists to predict which of these possible outcomes is likely to occur, yet both mechanisms do affect the world's climate. They are a part of the total process which changes the climate of the world, the radiative and heat balance process. Also included in the total process are changes in cloud cover and in the water vapor in the atmosphere. Other factors include the ocean-atmosphere transfer process in which heat is transferred from the atmosphere to the ocean and vice versa, and the hydrological process, concerning the amounts of ocean water, ice, ground water, and atmospheric water involved in evaporation, precipitation, and runoff.

According to UIUC Professors R. E. Klein of the Department of Mechanical and Industrial Engineering and L. D. Metz of the Department of General Engineering, all these conditions affect and change climate in a cyclic manner. They have hypothesized and are studying a limit cycle system — a systems engineering approach to climate theory.

Their nonlinear system theory, which discounts both doomsday theories outlined earlier, takes into consideration all the processes mentioned, calculates their interrelations and their reactions upon one another, and most importantly, examines the stability of the earth's thermal balance. The model they have developed could make possible quantitative calculations regarding climate change. The model, which is still being refined, is even now causing encouraging comment from climatologists and systems analysts.

This being the time of year for predictions of new ice ages, forecasts of altered climate and laments for good old-fashioned winters, Klein and Metz can say that worldwide climates are changing, but most likely neither an ice age nor a period of drastic rise in temperature will occur this winter. ●

FLYING INK SPOTS

Electrostatic copiers still fall far short of those magical fountain pens of Disney's which create scenes merely by squirting their contents on a drawing pad. However, the magic of flying ink may not be entirely out of reach.

The Charged Particle Research Laboratory at UIUC has undertaken a feasibility study for a high-speed, high-resolution electrostatic facsimile machine. The printing method might be described as a controlled spatter painting process.

A film of conduction ink spread over an electrostatically charged surface lies on one side of the paper to be printed. On the other side is a dense network of needle-pointed electrodes with an electrostatic charge opposite to the ink. Electrostatic attraction causes small amounts of ink to form opposite the needle points. When the charge on a particular needle becomes great enough, the sharply peaked ink mound emits droplets which "fly" to the paper.

The quality of the image produced is dependent on the density of points. The method being studied will have ninety-six points per inch. There are many advantages to such a copier. Any type of paper can be used. Other currently used processes require special spark sensitized paper or photographic paper. Any conducting ink with proper viscosity and volatility properties also works. And, control over the darkness of the print will be improved.

Flying ink spots are only distantly related to Disney's magical animations. They do have one feature in common, however; in both there is nothing faster on the draw. ●

OFF THE WALL

Even shingles have their moments, aerodynamically speaking. Their moments become especially important if the shingles in question happen to be those which are falling off the outside walls of the Krannert Center for the Performing Arts on the UIUC campus.

The shingles are four-pound ceramic roofing tiles, used to cover several large wall surfaces of the Krannert Center. The problem is that in many places the tiles have been blown off, giving the relatively new building a dilapidated appearance and making it dangerous for passers-by. To confirm suspicions that the culprit responsible for the removal of the tiles is the wind, the Department of Aeronautical and Astronautical Engineering was called in to investigate.

The project head, Professor H. O. Barthel, studied the problem by simulating a tile-covered wall section and measuring air pressure on the tiles in the UIUC wind tunnel. The pressure readings were converted to aerodynamic moments, a measure of force on the tiles. It was discovered that windy gusts over fifty miles per hour, not uncommon in this part of the country, exert a force approaching forty pounds of pressure on one of the two roofing nails used to hold each shingle in place. This outward force causes the nail to loosen, allowing the shingle to flap with the next stiff breeze. Eventually, the flapping movement loosens both nails and the tile falls.

Wind caused extensive damage at the Krannert Center for the Performing Arts on the UIUC campus by blowing many shingles from the walls. UIUC engineers determined the wind-induced forces on the shingles which led to the new fastening system applied by workmen.

The shingles are presently being replaced, and roofing adhesive and metal clips are being used this time, in addition to the nails, to hold them in place. Shingles may have their moments, but even so, they should be kept in their place. ●

UP FRONT WITH BACK SEAT DRIVERS

As every student knows, test results can have very little to do with how much one has learned. When driving ability is the subject to be tested, the correlation between test results and practical knowledge becomes a matter of public concern. In research now being conducted at UIUC, Professor John Conley of the Department of Health and Safety Education, with the cooperation of Professor John Baerwald, Director of the College of Engineering's Highway Traffic Safety Center, is trying to devise a state licensing examination for drivers which accurately predicts driving ability.

In 1967 Professor Conley and his associates began revising the Illinois state driver's license examination. Taking their questions from *Rules of the Road,* five test forms of fifty items each were compiled and distributed. Statistical analysis of these forms reduced the final test to five forms containing thirty items each. These tests were given to 50,000 drivers in a state-wide sample.

This summer, driving records for each of the 40,000 remaining members of the sample will be pulled from the office of the Illinois Secretary of State. They will be studied to discover if any correlation exists between scores on the written driver's test and the accidents or violations each person has accumulated. The researchers will also look for relationships between items missed on the examination and particular types of driving violations.

This is the first time any attempt has been made to scientifically evaluate the worth of a driver's test in practice, and the study has raised considerable interest at the federal level. The results of this summer's work will demonstrate how well the type of written tests currently used in most states measures actual driving ability. And aside from providing each licensee with his own backseat driver, this is the most critical test of driver ability that has yet been devised. ●

PEOPLE AND PLACES

The National Society of Professional Engineers has presented its 1972 award to Professor **Ralph B. Peck** of the Department of Civil Engineering for "leadership in engineering — and his outstanding excellence as an engineering educator."

Four grants totaling $35,000 have been presented to UIUC by the **E. I. Dupont de Nemours Company.** These include $15,000 to chemistry, $10,000 to chemical engineering, $5,000 to agronomy, and $5,000 to mechanical engineering to support teaching and research in those fields. ●

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inside outlook:

PHYSICISTS AID PALEOBOTANICAL RESEARCH
CIVIL ENGINEERS STUDY SUBWAYS
ANTENNA LABORATORY RENAMED
SYSTEMS ANALYSIS APPLIED TO LEMMINGS

PETRIFIED PEEK

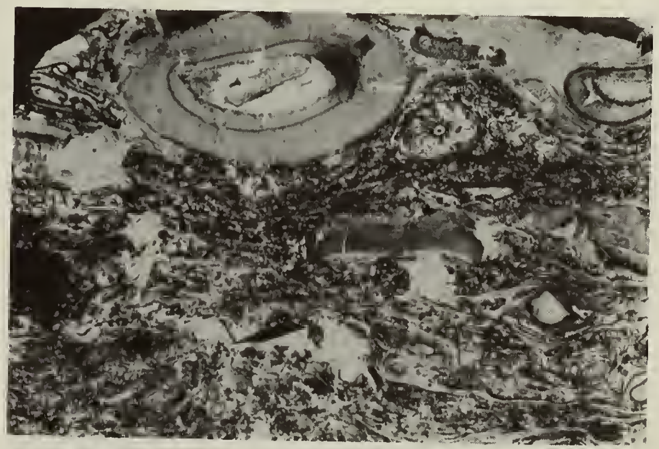
Three hundred million years ago parts of southern and western Illinois and western Kentucky and Indiana were covered by tropical swamps. Tree ferns and giant club mosses up to 100 feet high covered the area. Through the course of time, some falling trees in the swamp rotted, and others compacted and eventually became coal. Still others were entombed in calcium carbonate and are found today in the seams of coal deposits as large rocky masses of petrified peat, called coal balls. The coal balls have kept the original plant cells intact, and serve as time capsules for modern paleobotanical research on the formation and botanical constituents of coal.

More than forty tons of coal balls are now in the possession of University of Illinois at Urbana-Champaign, ranging in size from that of a fist to massive slabs of three feet or more. They are cut with a diamond saw into one-inch slices and then polished. The slice surface is etched with hydrochloric acid to dissolve the calcite, and the remaining cell wall material is embedded in cellulose acetate and studied. It is hoped that the remains will yield information about the changes in the coal swamp forests and lead to an understanding of changing environmental factors and the time involved in the coalification of plant material.

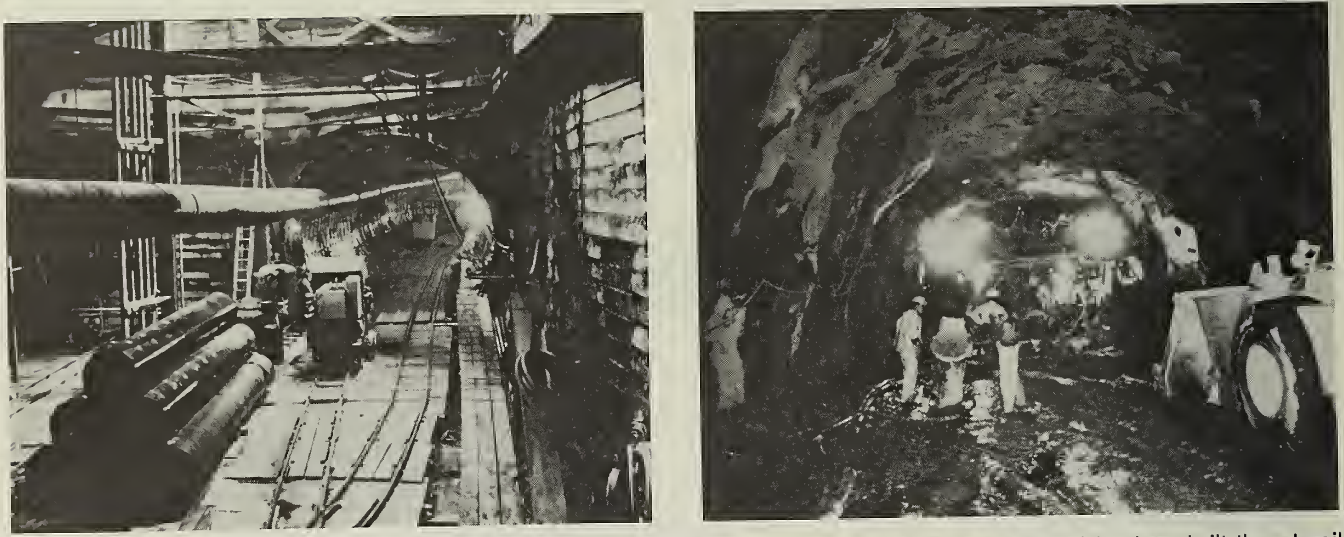
With tons of research material, and the great amounts of data collected from each coal ball, researchers in the Department of Botany needed a way to facilitate the extensive study. They needed to determine the exact sampling procedures to use and how to get the quantitative information without either cutting corners or overworking. They needed to know how much information of the twenty to thirty thousand pieces of data taken from each vertical section of coal balls was necessary to characterize the coal swamp forest through time.

UIUC Professor Barry Kunz and research associate Daniel Mickish of the Department of Physics are using their knowledge of computers and mathematics to aid in the research. Reliability and efficiency are their goals, and they are using a form of experimental statistics to achieve them. The computer predicts how much information from each coal ball is needed to yield complete records. The researchers initially took more than enough data and then tested that against the predicted required amount, only to find that the extra information they gathered as a precautionary measure was, as the computer had predicted, extraneous. In addition, the computers have aided the paleobotanical researchers in thousands of man-hours of calculations.

Even though the computer has cut down the required information to approximately one box of computer cards per coal ball, there is still a vast amount of data to be tabulated. It is in line with the research, though, that in the study of swamps they are swamped. ●



This photograph of a cellulose acetate peel of 300-million-year-old plants taken from coal balls, or petrified peat, is an example of Herrin Coal from southern Illinois. The large oval in the upper left is a cross section of the woody branch of a giant club moss, and the small flowerlike structure to the immediate right is the cross section of a cone from the same tree.



Tunnels far the Washingtan, D.C. subway system are being built through bath rack and sail. On the left the tunnel has been built thraugh sail using a shield which is driven into the sail by hydraulic pressure, leaving a perfectly symmetrical hale. The tunnel an the right has been built thraugh rack, blasted aut part by part.

ENGINEERS MOVE UNDERGROUND

When the French architect L'Enfant designed the city of Washington, D.C. in 1791, he was careful to take into account any possibility of invasion by foot soldiers. In designing for national security, however, he inadvertently made the city impossible for modern transportation. Taking up where L'Enfant left off, a team of civil engineers from the University of Illinois at Urbana-Champaign is putting the same effort into the building of the Washington Metropolitan Area Transit System. The new subway, better known as the Metro, will run underneath the city of Washington and surrounding suburbs.

The goals of their project, which has been in progress since 1970, are to both increase the safety and decrease the cost of building approximately fifty miles of underground tunnels through soil and rock. In addition, care must be taken during construction to preserve historic buildings in the nation's capital. Of paramount importance to the Illinois engineers are the geologic formations through which the tunnels are being built. By relating the effects of geology and construction procedure to rock and soil movements, they hope to accumulate data to justify change and improvement in future tunnel construction.

Approximately fifteen miles are being tunneled through rock. The rock is dislodged by blasting, and the loose rock is then cleared from the site in muck cars. Steel arches are erected every four or five feet to support the tunnel. The research involves examining in detail the geology of the area, with specific attention to the rock load on the supporting structures. Another facet of the measurement program entails the use of UIUC-designed extensometers to measure movements in the rock. Developed especially for this project the remote reading extensometer can be placed anywhere in the tunnel to send back accurate readings of rock movements electrically, even through adverse conditions of blasting and moisture.

The most difficult job is the building of the Dupont Circle Station, a 45-foot high by 75-foot wide by 700-foot long tunnel through rock. This phase, started last year, is expected to take a full three years to complete and will result in one of the largest underground stations in the world. This structure is so large that it must be excavated in six drifts. The rock displacement measurements provided by the Illinois researchers have guided the excavators in determining the size of each individual tunnel opening with regards to maximum safety.

The rock tunnels, which are 75 to 100 feet underneath the ground, can often be relied upon to support their own weight, at least for a short distance. Not so with the tunnels dug through soil. The wrong construction procedure can easily cause the surface over the tunnel to settle, causing extensive damage to buildings on the surface. To tunnel through soil, a shield must be used. The shield is a large circular steel structure which is pushed through the soil by hydraulic jacks. Workers erect the tunnel lining behind them and remove loose dirt as the shield is pushed forward.

The third phase of the study centers around the Gallery Place Station. The subway tunnel is built here by cut and cover methods; the soil is temporarily supported by cross-cut braces until a concrete structure is built. Instrumentation of soil movements, displacements, and forces on the supports are crucial here also.

Washington, D.C. is just one of many cities in some stage of planning and executing a metropolitan rapid transit system. The civil engineers' next move is to Atlanta, Georgia, where they will apply the knowledge they gained in Washington to new tunnels and gain new knowledge working with different geologic formations. ●

ANTENNA TO ELECTROMAGNETICS

When members of the University of Illinois Antenna Laboratory found themselves working not only with antennas, but also with plasmas, analytical and computer-aided methods for electromagnetics, optical processing, holography, direction finding, biomedical and environmental remote sensing, and communications, they decided that, given a choice, it would be better to change their name than to drop their diversified research. This spring the twenty-five-year-old Antenna Laboratory was rechristened the Electromagnetics Laboratory.

The laboratory is one of the oldest in the UIUC Department of Electrical Engineering. Professor E. C. Jordan, current head of the department, was laboratory director from 1950 to 1955. Professor Victor Rumsey took over the directorship in 1955 and served until 1958. It was during this time that the log-periodic antenna, which made the laboratory world famous, was invented. According to Professor George Deschamps, laboratory director since 1958, electromagnetics does not mean the study of electromagnets. It is rather the study of the broad subject concerned with the fields or waves produced by the motion of electric charges and the effects of these fields on other charges. "Antennas are still an important part of our concern," stated Professor Deschamps, "but we believe that the new name describes our present activity best." ●

ANALYZING THE LEMMING MYTH

To destroy everyone's fondest notions at one fell swoop, the moon is not made of green cheese, Santa Claus does not live at the North Pole, and lemmings do not compulsively jump off cliffs into the ocean.

Although most adults have outgrown the first two, the myth of the self-destructive rodent persists. According to Norwegian legend, hordes of lemmings periodically come to the shore and cast themselves into the sea. Though legend does not explain the reasons behind the supposed self-destructiveness of these tiny arctic rodents, their migration and suicide have been unquestioned and accepted.

UIUC professor R. E. Klein of the Department of Mechanical and Industrial Engineering is using a modern engineering technique to dispel this old myth. By applying systems analysis to the population cycle of lemmings, Professor Klein hopes to predict their behavior.

The facts are that every three, four, or five years the lemming population multiplies a thousandfold. Instead of one lemming for every ten acres of land, in the years of the high population, 100 lemmings per acre are found. Because lemmings live in burrows under the snow, they literally multiply in secret during the winter months. After the snow melts and before new burrows are dug in high unfrozen patches of ground, there is a seemingly sudden and inexplicable increase in the number of lemmings. The population returns to normal within two months after the spring thaw, due to causes not yet understood, but thought to include the competition for food and the existence of various predators.

The possible relationship between the behavior of lemmings and the behavior of man in regards to population makes the study of lemmings more than just the study of a natural oddity. Explanations for their cyclical swings in population have been proposed, but none give a full explanation. The swings have been attributed, for example, to sunspots, weather, and the existence of predators. One by one these external explanations have been disproven. A more recently proposed solution to the mystery lies in the possibility of a genetically driven biological clock, along with the effects of stress generated by continued population growth.

Because their behavior is cyclical, and not dependent on any one cause but rather upon the interaction of several forces, the subject is open to research by the systems and control systems engineer. Professor Klein postulates the lemming cycle as a nonlinear feedback control system, and is attempting by computer simulation to devise a mathematical equation which will account for the lem-

What seems to be a herd of lemmings scurrying toward the sea actually is a legend inspired by their erratic population cycle. UIUC researchers are applying systems theory to explain their population growth cycles.

mings' natural cycles. Perhaps more importantly, he is using the lemmings as a teaching device to demonstrate to students the relevance of systems theory to broad and diverse problems.

In addition, his students are learning that a blind lemming-like acceptance of "common knowledge" is no substitute for a rational analysis of the facts. ●

IMPROVED OPPORTUNITIES FOR ENGINEERING GRADS

The engineering employment situation has improved greatly over the past year, and more midyear UIUC engineering graduates have been hired this year than at any time since 1970. Forty-six percent of the midyear graduates have obtained jobs prior to graduation this year, compared to 35 percent in 1972. And beginning salaries are higher too — up $53 per month from the 1972 midyear low. This changing trend can be clearly seen in the field of aeronautics. Last year eight of its thirty-five graduates remained unemployed; this year only one of the twenty-three graduates was still available. ●

PEOPLE AND PLACES

Professor **Clyde E. Kesler** of the Departments of Theoretical and Applied Mechanics and Civil Engineering has been awarded honorary membership in the American Concrete Institute.

James W. Bayne, Professor of Mechanical Engineering and Associate Head of the Departmental of Mechanical and Industrial Engineering, has been elected President of the Association of College Honor Societies.

Professor **Donald L. Bitzer,** Director of the Computer-based Education Research Laboratory and Professor of Electrical Engineering, will receive the Vladimir K. Zworkyn Award of the National Academy of Engineering. He is selected for "outstanding achievement in the field of electronics applied in the service of mankind."

Stanley N. Roscoe, Professor of Aeronautical and Astronautical Engineering, has been asked to present papers at a NATO conference on man-machine systems to be held in Utrecht, The Netherlands, and also at the International Congress of Institutes of Navigation in Hanover, Germany. ●

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engineering outlook

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 14, NO. 9, MAY 1973

inside outlook:

ELECTROMAGNETICS LABORATORY STUDY HOLOGRAPHY
LOWERED NOISE IN OFF-ROAD MACHINERY SOUGHT
LIQUID CRYSTALS USED TO SEPARATE ENZYMES
DIRECTOR OF ENGINEERING PLACEMENT RETIRES

MANY HANDS MAKE LIGHT WORK

Flash Gordon's light-ray gun zaps the Venusians before they grab the secret rocket plans. Superman's x-ray vision uncovers the kryptonite hidden in Luthor's wooden leg. And Professors Mittra, Ransom, and Itoh trip the light fantastic with lasers, light, and holograms at the University of Illinois at Urbana-Champaign.

P. L. Ransom and Raj Mittra, Professors of Electrical Engineering, are working on the computer synthesis of holograms. Holography is a process comparable to photography which, by using laser's coherent light, produces three- rather than two-dimensional images. Each image has depth as well as width and height, so each hologram contains within it information not only of the image at one angle but of the image at all angles, a kind of picture-sculpture.

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To completely synthesize such a hologram by using the computers available today is impossible. The amount of information contained in even one hologram is too immense for a computer to handle. Simplified hologram simulation is possible, however, and can be achieved in more than one way. Professor Ransom's and Professor Mittra's project is to find the best of the several methods of artificially producing holograms, the critical factors being low cost, high resolution, ease of production, and reduced time.

The second portion of this project is to find practical applications of hologram synthesis. For instance, they plan to extend the principles of holography to other ranges in the frequency spectrum, such as acoustic and suboptic waves. By recording the suboptic wave scatter, transferring it in the computer from suboptical to optical frequency, and using the computer to produce a simple hologram, they will be able to "see" inside objects that light cannot penetrate. This Superman-type vision can be used to detect concealed metal objects, flaws in rocket fuels, and most importantly, tumors in the human body.

Professors T. Itoh and Mittra are working on another way to transmit information through the use of coherent light. They are designing optical fibers that can replace telephone wires in intracity telecommunication. This will be useful as computer-to-computer communication becomes more necessary, because optical fibers can be made smaller and carry up to fifty million times the amount of information carried by a telephone wire.

The three professors, a coherent group in coherent optics, are diligently turning science fiction into science fact. All they need now is H. G. Wells' time machine to find out what effects their versions of Flash Gordon's laser and Superman's x-ray vision will have on the world. ●

PASTORAL PANDEMONIUM

City dwellers probably picture the country as a scene of quiet tranquility. Unfortunately, those who are most often out there away from it all are usually rattling around on the seat of a tractor or other piece of machinery which surrounds the operator with an uncomfortable and perhaps unhealthy amount of noise.

The University of Illinois at Urbana-Champaign, near the center of the world's largest concentration of agricultural machine production, is also the center of much concern over the design of tractors and other off-road vehicles to function within the comfort level of the operator. Currently Professors R. Yoerger and J. A. Weber of the Department of Agricultural Engineering are working on reducing the noise and vibration levels of individual systems common to off-road vehicles. There are several problem sources in heavy machinery besides the vibration resulting from the reciprocating engine, but the two on which most effort is being concentrated are the cooling and exhaust systems.

Cooling systems on automobiles usually are not considered a noise nuisance because much of the cooling effect is supplied by air forced through the radiator as the car travels at high speeds. Slow-moving off-road vehicles cannot rely on this natural cooling, and so require powerful high-speed fans to keep them from overheating. Increasing the speed at which a fan turns increases the noise level, of course, but other factors, such as the size and position of obstacles both in front of and behind the blade, and a phenomenon known as stalling, affect the sound level. The two researchers have been gathering precise data on the effects of speed and obstructions on the overall noise level. This study yielded some general rules for fan design and for the optimum spacing between radiator, fan, and engine. However, it was found that stalling, which is caused by uneven airflow on the fan blade, can make the noise level as much as thirty-two times more intense. Stalling occurs when an additional restriction develops in the incoming airflow against the fan blades, and in the field can be caused by something as simple as chaff being sucked against the radiator. Efforts are now being made to analyze the conditions present at the fan blade surface during stall by taking sound pressure measurements within close proximity of the blade.

The second area of research concentrates on the exhaust system. Along with the chemical products of combustion, the exhaust system also carries the alternating pressure waves produced in the engine out into the air. Reactive mufflers are common in heavy machinery and work as reverse pipe organs to nullify the noise of certain low frequencies produced by large engines. The pressure waves are channeled, separated, and reflected in the muffler, and cancelled against one another by paths of wave reflection designed into the muffler. Maximum cancellation requires a knowledge of the characteristics of the waves entering the muffler. The professors have developed mathematical models of waves flowing from the engine through the manifold and into a muffler of proposed design, which predict the amount of noise which is eventually heard. Experiments are also being conducted concerning the mechanical noise generated by the mufflers' vibration, testing factors such as shape, thickness, and dampening agents for their effect on the noise level.

This engine cooling fan test stand measures sound from the cooling system of off-road machinery. It is a part of a study of noise and vibration in farm and other off-road vehicles currently being conducted by the UIUC Department of Agricultural Engineering.

This research, in its efforts to muffle the muffler and the cooling system, is quietly making it easier on the operator and improving the overall efficiency of the machinery. The improvements this project will generate, both in machine operation and operator comfort, proves once again that in the country, as well as the city, silence is golden. ●

ENZYME SIFTER

Anyone who was ever at the beach can tell you that a sieve holds in the pebbles and sifts out the sand, but it is doubtful that there has been a sieve that would separate the black pebbles from the white ones. On a more complicated and more useful level, Professor Allen Kozinski of the UIUC Department of Chemical Engineering is trying to develop just such a sieve.

He is experimenting with methods of separating biochemicals — particularly enzymes which cannot be synthesized outside of a biological environment — from larger combinations of similar and dissimilar compounds. The enzymes which he is trying to isolate are useful in more areas than clean laundry. They are used for oxygen detection, to find trace pollutants, for the treatment of cancer, and for the industrial conversion of starch to sugar. The isolation of high-purity enzymes is more than a piece of interesting experimental research.

Most commercial means of separating enzymes currently used employ industrially produced membranes, built on the same principle as the sand sieve, with microscopic holes which serve to sift one compound in solution from another. Professor Kozinski is attacking the problem from a different direction. His method makes use of dynamic membranes. Unlike fixed membranes, or filters, dynamic membranes are liquid crystal phases which form from the liquid solution, having both the flowing qualities of the liquid and the structure of a solid.

Fibrinogen is the compound being studied most extensively at the present time. Fibrinogen forms a liquid crystal layer only a few millionths of an inch thick, which currently can separate lysozyme and tyrosine from solution.

The fibrinogen film cannot clog, as drains clog, because it is made of liquid. The filter film is constantly being replaced by the flow of solution through it. The solution flow can also change the properties of the filter. By changing the velocity, direction, and concentration of the flow, the configuration of the crystal membrane also changes, enabling the same liquid crystal to selectively separate more than one enzyme.

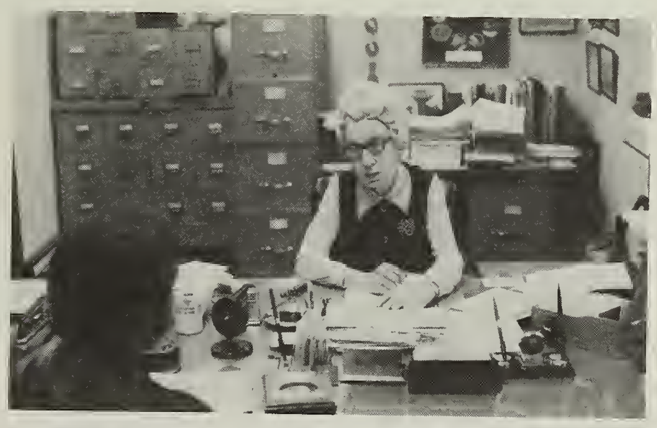
Dynamic membranes have the advantage of separating enzymes more quickly, and on a larger scale, than artificial membranes. Dynamic membranes present the possibility of programmed separation by control of the solution environment and in addition are nontearable and easily maintained. The dynamic membrane functions as a molecular gate, and in effect separates the black pebbles, or enzymes, from the white. ●

SHE PUT EVERYONE IN HIS PLACE

The first lady of engineering placement at the University of Illinois at Urbana-Champaign will retire in August after eighteen years of service to the College of Engineering and twenty-seven years of service to the University. Mrs. Pauline V. Chapman, under whose directorship the Engineering Placement Office achieved national recognition, announced her retirement in April.

When Mrs. Chapman took over the directorship of the Engineering Placement Office, it was little more than a bulletin board in the office of the associate dean. She was given full rein to improve the office and began immediately.

Under her direction an available alumni list was created as a service for alumni seeking to change jobs. These lists are circulated monthly to industry which in turn contacts the alumni directly. Mrs. Chapman also initiated the valuable end-of-semester salary reports. She was one of the leaders in identifying and accumulating definitive salary data which give industry a basis for setting salary scales. Her initial surveys are expanded by annual five- and ten-year follow-ups, invaluable guides to those seeking information about salary structures and as comparisons of those with and without advanced technical training.



Mrs. Pauline V. Chapman, Director of Engineering Placement at the University of Illinois at Urbana-Champaign since 1955, advises senior Anthony Brown on future employment opportunities.

Many of Mrs. Chapman's programs are student oriented, designed to aid the student in finding employment. Each graduating senior who requests help receives an interview number, and may sign up for specific interviews with industry recruiters visiting the campus. Another aid is the library of company literature, which allows students to better inform themselves of the opportunities available to them at individual companies. Another program started under Mrs. Chapman's guidance is the annual meeting each fall with the new senior class. At these meetings suggestions are made to the students to help them prepare for upcoming interviews, and a mock interview is held with a recruiter from industry and a student. A second meeting was initiated last year to discuss with senior students problems associated with plant visits.

Mrs. Chapman also served as one of the five members of the first assembly of the Midwest College Placement Association, a duty equivalent to membership on the board of directors. The high regard in which she is held by industry is illustrated by a comment in one company's internal newsletter. "Ask a man who recruits engineers to name three women whom he considers most important to him. More than likely he'll reply, 'My wife, my mother, and Pauline Chapman.' " ●

THE ENVELOPE, PLEASE

Election to the National Academy of Engineering is the Emmy of the engineering profession. This year, out of twenty-five members elected from universities, three professors of the UIUC College of Engineering were honored by the academy. The three elected are Nick Holonyak, Jr., Professor of Electrical Engineering, Ven Te Chow, Professor of Hydraulic Engineering, and Mac E. Van Valkenberg, Visiting Professor of Electrical Engineering.

Professor Holonyak was elected for "contributions to development of semiconductor controlled rectifiers, light emitting diodes, and diode lasers"; Professor Chow for "developments in hydrological analysis, stochastic hydrology, water resources systems analysis, and watershed hydraulics"; and Professor Van Valkenberg for "contributions to circuit theory, beacon antennas, servomechanisms, and computer science." ●

PEOPLE AND PLACES

This year six men received the UIUC College of Engineering Alumni Honor Awards for Distinguished Service in Engineering. They are: **Mr. H. Ashley Barber,** of Barber-Greene Co., Aurora, Illinois; **Dr. Sidney D. Drell,** with the Stanford Linear Accelerator Center, Stanford, California; **Mr. Walter E. Hanson,** of Hanson Engineers, Inc., Springfield and Peoria, Illinois; **Dr. Robert H. Page,** of the Department of Mechanical and Aerospace Engineering, Rutgers University, New Brunswick, New Jersey; **Mr. John H. Thomas,** of Owens-Corning Fiberglas Corp., Toledo, Ohio; and **Dr. F. Wheeler Loomis,** Professor Emeritus of Physics at the University of Illinois at Urbana-Champaign.

The UIUC Everitt Award for Teaching Excellence has this year been presented to **Professor Ernest J. Barenberg** of the Department of Civil Engineering and **Professor Gary L. Hogg** of the Department of Mechanical and Industrial Engineering. The Stanley H. Pierce Award for development of student-faculty empathy and cooperation went to **Professor Arthur L. Friedberg,** Head of the Department of Ceramic Engineering, **Professor Herman Krier,** of the Department of Aeronautical and Astronautical Engineering, and **Joseph J. Sarmiento,** senior in general engineering.

Professor B. T. Chao of the Department of Mechanical and Industrial Engineering has received the 1973 American Society for Engineering Education Western Electric Fund Award for Excellent Teaching.

Arthur B. Chilton, Professor of Nuclear Engineering and Civil Engineering, has been elected to council membership of the National Council on Radiation Protection and Measurement.

Professor John Bardeen of the Department of Physics is the first recipient of the James Madison Medal honoring an alumnus of Princeton University's graduate school. ●

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COLLEGE OF ENGINEERING
VOL. 14, NO. 10, JUNE 1973

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inside outlook:

SELF-CHECKING COMPUTERS
COMPUTERIZED MUSIC
RACETRACK MICROTRON ELECTRON ACCELERATOR
CONCRETE CANOE RACE
PROBLEM-ORIENTED LANGUAGE ORGANIZER

COMPUTER, HEAL THYSELF

If computers had necks, they might be able to wear a string of garlic around them. However, this method of preventing malfunction in computers sacrifices efficiency for low cost. Other methods, with more balanced proportions of emphasis on cost, efficiency, and accuracy are being devised at the UIUC Coordinated Science Laboratory to keep computers healthy.

According to Professor G. Metze there are three ways to handle unavoidable computer component failures. One is to test the entire system periodically, perhaps once or twice daily. If problems appear, they can be localized and repaired. However, everything the computer has done since it was last checked must be recomputed, since there is no way of telling when the problem occurred.

Another method used most often when short-term, high-accuracy performance is required, such as on space flights, is fault masking. One implementation of this method replaces single circuit modules by triplicated circuits together with majority voting elements, so in case of failure of one circuit in the module the output of the majority is still correct. Of course with this method the additional equipment can increase the failure rate, because there is much more equipment to malfunction.

The third method, a combination of the two mentioned above, is one on which Professor Metze is spending most of his time and effort. This method utilizes both software and hardware approaches to achieve a "self-checking" digital system. All information in the system is encoded in an error protection code, and monitors are added at strategic locations to continuously check for failure indications while the computer is in use. Professor Metze and his associates are in the process of designing a small self-checking computer. They are deciding what codes will both protect against faults and also be easily workable and where the check points are to be placed. Their most difficult problem is in guaranteeing that every malfunction leads to a failure indication.

The advantages of a fault-tolerant digital system are seen mostly in its economic efficiencies. Such a system would make it unnecessary to rerun computations and would use less equipment than the triplicated method. Professor Metze expects the design and construction of his fault-tolerant system to take a number of years, after which time he will be able to show us a self-diagnosing computer; thus, simultaneously removing the need for garlic and a real stinker of a problem. ●

SOUNDS LIKE . . .

Until recently, computers were mostly seen and not heard. However, under the direction of J. W. Beauchamp, Professor of Music and of Electrical Engineering, it seems computers may soon be giving music recitals and performing in concerts. At least those are quite possible results of some of the projects at the experimental music studios of the UIUC School of Music.

One project is computer synthesis of authentic instrument sounds. First, the computer is used to analyze and graph actual wave characteristics of a note from an instrument being played into a microphone. Then close approximations to the analyzed wave are found which are much simpler to reproduce than the original wave. The aim is to cut corners on computer time and lower reproduction costs, while only slightly reducing the quality of the synthesized sound. This optimum simplification approach is almost the opposite of the build-up process of most synthesizers, which rely on trial and error for producing and improving their tone quality.

In another part of the studio a small computer is being programmed to compose pieces to be played through a noncomputerized electronic synthesizer. By restricting the computer's random compositions, it is possible to tell the computer the type of music desired and to receive a new and almost human (if that's what was asked for) composition on the spot.

A combination of these two projects, and other studies being done by students of the School of Music and various engineering departments may someday lead to an "ultimate instrument" which would allow the artist to fully express himself musically with practically no technical limitations.

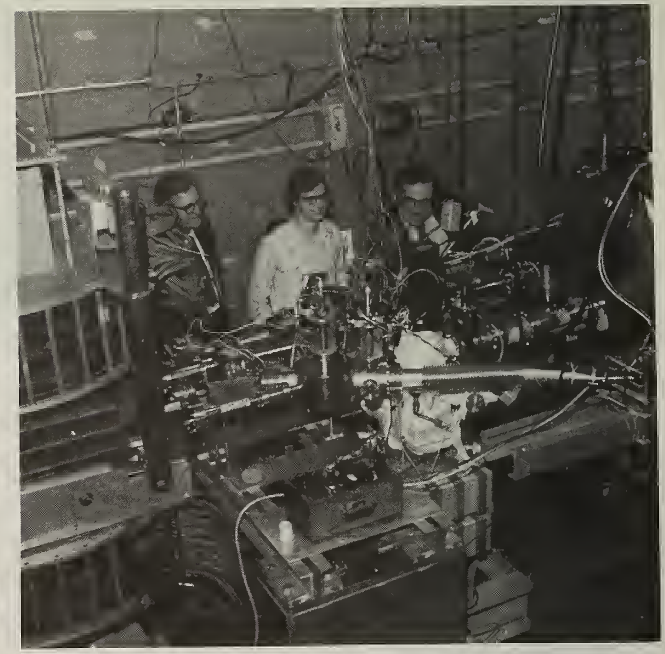
Music has stepped in time with the rest of the world since the advent of the hollow log drum, and still has never changed its basic nature. Doubtless, a random composition computer would hold as much in the way of surprises as Haydn's famous symphony. With the help of the UIUC experimental music studios, we may shortly hear some of them. ●

THE RACE IS ON

. . . and at the finish it's electron beating e^- by a "wave"-length, and setting a new track record averaging 99.9 percent the speed of light. Such exciting racing action is occurring continuously at UIUC's racetrack microtron under the supervision of professors P. Axel, A. O. Hanson, and J. S. Allen of the Department of Physics. This accelerating jog around the track is only a warm-up for the participating electrons whose real purpose is the bombardment of an experimental target for research on nuclear structure.

The microtron is an electron accelerator. As tools go, the racetrack microtron using a superconducting linac is one of a kind, incorporating several novel technological advances aimed at yielding a continuous high-quality electron beam.

The component that does the actual accelerating, aside from the electron gun which injects the electrons on the track, is a linac, short for linear accelerator. It has been supercooled with liquid helium to 4.2°K, almost to absolute zero. The superconducting effect thus achieved greatly reduces the power loss involved in generating and maintaining the 1.3 GHz (billion cycles per second) accelerating waves along which the electrons surf to gain energy. This low power loss makes it economically and materially feasible to keep the linac running continuously. However, the linac is only 6 ft long, in fact the whole machine including the electron gun is only approximately 40 ft long and 6 ft wide, and electrons coming out after only one pass have an energy of 3.5 MeV (million electron volts). Van De Graaff electrostatic-type accelerators can operate effectively up to only 5 MeV and always supply a continuous beam. In order to get an energy beam above the available 5-MeV range, the electrons in the microtron must be accelerated through the linac more than once.



A racetrack for electrons looks like this. The linac, located at center right, accelerates the electrons; the large magnets located at center left curve the path of the electrons for repeated trips through the linac. The linac, 6 ft in length extends to the right of the photograph. Pictured are Professors Axel and Hanson who built the novel UIUC racetrack microtron.

Getting double and triple use out of the small linac has been accomplished by using two large bending magnets. The electron beam leaves the linac the first time traveling west, enters the west magnet, moves in a semicircle, and emerges traveling eastward. After moving parallel to the linac for about 25 ft a similar magnet turns the beam back into the linac which is still working accelerating other electrons on their first lap. The distance between the magnets is adjusted so that the beam returns to the linac in proper phase for maximum acceleration.

The racetrack microtron is presently operating on three passes at an energy of 10.3 MeV. In a few months three more tracks will be added which should boost the power to 20 MeV. Further improvements in the accelerator sections could boost the power to a maximum of 60 MeV.

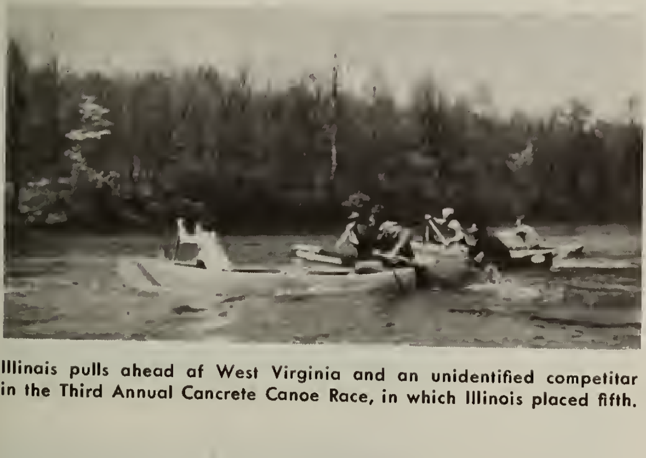
The high number of electron volts and the relatively small size of the machine are impressive. However, the most important characteristic, according to Professor Hanson, is the continuous flow of the electron beam. Other electron accelerators operating at high energies create very short pulses of electrons. The percentage of time that electrons are actually striking a target, called the duty factor, is important since the rate of collecting data in some experiments is directly proportional to the duty factor. In those types of experiments, the new microtron could collect in a few hours the same data that might have taken pulsed machines days or weeks to collect.

An energy of 20 to 60 MeV is not so spectacular compared to the 20 GeV (billion electron volts) of Stanford University's two-mile linac, or the 2000 GeV developed in some colliding beam experiments. But bigger is not necessarily better, and different energy ranges are used to study different things. A 20-MeV beam cannot smash a proton, but using a 300-GeV beam to study nuclei would be like trying to study intact egg yolks by using a shotgun to crack the shell.

The experience gained in developing and operating the individual components of the microtron may lead to practical results in other applications in the near future. For instance, working with supercold to reduce power loss in the linac may aid in the development of high power channels capable of moving the millions of watts of power produced by distant electric power plants to a centralized distribution point without power loss. Knowledge about atomic structure, magnetic focusing, and electron beams will also be gained. The professors aren't taking any bets, but it looks now as if in this race there won't be any losers. ●

CONCRETE CANOE

A canoe made of concrete seems hardly likely to float, much less win a race, but race it does, and Professor Clyde Kesler of the UIUC Departments of Civil Engineering and Theoretical and Applied Mechanics has started everyone paddling his own. Professor Kesler's original idea was to use the construction of a concrete canoe to give his civil engineering students first-hand knowledge of the versatility and applications of concrete.



Illinois pulls ahead of West Virginia and an unidentified competitor in the Third Annual Concrete Canoe Race, in which Illinois placed fifth.

Purdue University heard about the project, and the race was on. That race, between the concrete canoes built by engineering students at Illinois and Purdue, was in 1971. This year's race expanded into an international competition among twenty-seven schools, from as far away as Nebraska, West Virginia, and Ontario, Canada.

The UIUC entry was made of concrete reinforced with half-inch glass fibers, hand-troweled over a steel bar and hardware cloth frame. Flotation chambers were built into each end. The canoe weighed only 260 pounds, heavy when compared to eighty-pound wooden canoes, but also eighty pounds lighter than last year's 340-pound entry. The aggregate used in this year's canoe was styrofoam pellets, making the concrete mix itself light enough to float.

Concrete canoe racing is not confined to the Midwest. Races have been reported in California, Oklahoma, and Pennsylvania. This has all begun since Professor Kesler's notion to exercise his students' imaginations as well as their memories. Concrete for canoes will never replace wood, but it does give students an opportunity to learn with enthusiasm for their subject. ●

POLO ANYONE?

In this case POLO is not the familiar game played by the social elite, but a very practical new computer system developed by the Civil Engineering Systems Laboratory (CESL) of the University of Illinois at Urbana-Champaign. POLO is an acronym for Problem-Oriented Language Organizer.

CESL fosters new ideas and techniques of computer use in civil engineering and transfers them to the engineering profession through a cooperative research and development program with contracting and consulting engineering firms throughout the United States. CESL applies its research to real problems and receives direct feedback from industry. The participating firms have access to one of the country's most advanced construction management and analysis systems. It is a unique arrangement with something for everyone.

Many of the programs available at CESL interact directly with the user, and all are accessible through problem-oriented languages (POLs). POLs provide a convenient method for users to communicate with the computer. In general, contractors "talk" with the computer in terms of day, dollar, and labor units and use a language tailored to estimating costs and projecting manpower requirements. Structural engineers use a different language, one more suited to calculating stresses on beams and the load-bearing capacity of members.

Although current emphasis at CESL is on construction management, the lab is also working in structural design and transportation and hopes to develop POLs for these areas in the near future. But development of a new POL from scratch is a lengthy and cumbersome task. This is where POLO enters the picture; POLO is a tool to aid in the development and implementation of new POLs.

POLO is a supervisory computer software system which, in addition to facilitating the generation of new POLs, greatly simplifies information storage and retrieval. It contains completely automatic engineering data management and a dynamic memory system which allows the programmer to assume a virtually infinite memory. All the operations of POLO can be initiated by an easy-to-use language (which is itself a POL), making POLO readily available to both the engineer and the programmer.

Many of the POLO capabilities are based on earlier CESL developments. However, many new features, including a multiple-file virtual memory system for permanent storage of data, have been added. This new combination of features promises to make POLO an extremely powerful computing tool.

Further information about POLO may be obtained from *POLO II General User's Manual* ($2.50) and *POLO II Programmers' Guide* ($5.50). Both documents are available from the Engineering Documents Center, 208 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. Orders for less than $5.00 must be accompanied by payment. ●

PEOPLE AND PLACES

Ronald L. Elliott, senior in agricultural engineering, has received the American Society of Agricultural Engineers' John G. Sutton Memorial Award as the "agricultural engineering student of the year, 1972."

Professor **Jerry S. Dobrovolny,** head of the Department of General Engineering, has been named President-elect of the Illinois Society of Professional Engineers.

Arthur B. Chilton, Professor of Nuclear Engineering and of Civil Engineering, has been elected to the National Council on Radiation Protection and Measurements.

Professor **Charles A. Wert,** head of the Department of Metallurgy and Mining Engineering, has received an alumni achievement award from Morningside College, Sioux City, Iowa, where he graduated in 1941. ●

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COLLEGE OF ENGINEERING
VOL. 15, NO. 1, SEPTEMBER 1973

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inside outlook:

STUDENT-DESIGNED HYBRID ELECTRIC VEHICLE
UNDERGRADUATE RESEARCH ON NITRATE POLLUTION
LIFE-SUPPORT SYSTEM DESIGN FOR EGGS
EDUCATIONAL PROGRAM
ON MOBILE HOMES AND WIND DAMAGE

EDITOR'S NOTE

Although the fact is seldom publicized, engineering students at UIUC do research at the undergraduate as well as the graduate level. The undergraduate researchers are hampered by lack of time (many of the projects must be concluded within one semester), lack of money (grants and funding for undergraduate research are scarce), and lack of experience. Even so, many of the projects which have been conducted are worthy of mention. To start the 1973–74 school year, *Engineering Outlook* has devoted this issue entirely to a review of undergraduate research.

By no means could we include all the projects. We have, however, compiled a cross section of research which demonstrates both problems involved and results obtained. Undergraduate research generates both practical solutions to problems and provides a real-world learning experience for those involved — benefits which are just as desirable at the undergraduate level as they are at the graduate level. ●

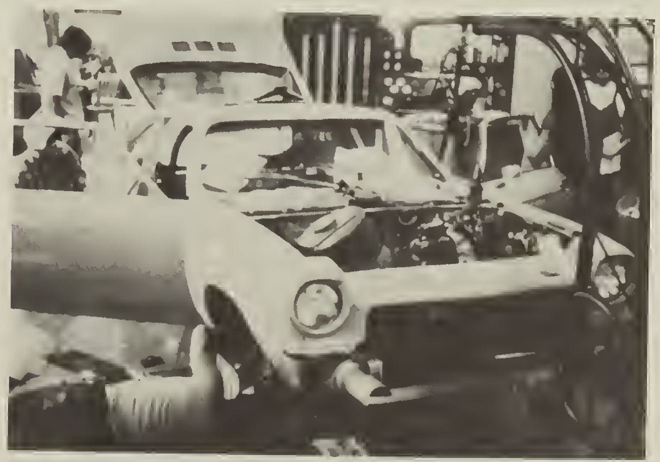
ELECTRIFYING RESEARCH

They told the Wright brothers, "You'll never get it off the ground." They're saying the same thing to the hybrid electric vehicle group at UIUC, but the group doesn't care. On the ground, their vehicle, when completed, will run more economically than any automobile available today, and in addition, break records for pollution control.

The original purpose of the project was to design an automobile to enter in the 1972 Urban Vehicle Design Competition. Late in 1970, the group, consisting of electrical engineering, mechanical engineering, and industrial engineering undergraduates, began design plans. They chose to design and build an ac hybrid electric vehicle because of the low pollution characteristics of a small engine operating at constant load and speed, the trouble-free nature of an ac transmission and drive system, and the real possibility that a vehicle of that type would be competitive in cost and performance with the standard internal combustion automobile.

The vehicle's wheels are driven by an electric motor through a conventional transmission. Energy for the motor is from a bank of storage batteries and a generator driven at a fixed speed by a 350 cc motorcycle engine. For acceleration and at other times when more energy is needed, the motor draws current from both generator and batteries. When the motor requires less current than the generator produces, the excess recharges the batteries.

The plan is advantageous in that the drive energy is independent of the engine output. Fluctuations of power at the wheels do not affect the engine. The engine, running at constant speed and constant load, can be set up for maximum efficiency and minimum emissions, yielding both low pollution and high gas mileage.



A donated chassis houses a hybrid electric drive system developed by an undergraduate research group at the University of Illinois at Urbana-Champaign. The vehicle, originally conceived as an entry for the 1972 Urban Vehicle Design Competition, is a result of the efforts of more than forty electrical, mechanical, and industrial engineering students.

Safety features of the vehicle include built-in rollbars and bumpers capable of absorbing an impact at five miles an hour without damage.

The students have been working with an extremely low budget. There has been almost no funding available for the project, and this problem has turned the project into a three-year affair. Most of the parts have been donated by industry, making it necessary for the students to plan around parts which did not exactly fit the parameters of their design. In addition, delivery of parts could never be guaranteed.

On the positive side, these undergraduates designed and assembled a unique dc to three-phase ac inverter to channel energy from the generator and batteries to the motor. This difficult task was accomplished entirely through student efforts, with minimum direction from the project adviser.

The vehicle should be operational this month. As soon as they get the car on the road, the group can begin testing its performance characteristics. The hybrid electric vehicle is expected to perform best on short distance, intracity runs where speeds are low and stops and starts frequent.

More than forty students have worked on the vehicle over the three-year period. Few members of the original team are still on the UIUC campus. One member of the original group, Bill Burtness, now heads the group and is using the inverter as a thesis topic for graduate work in electrical engineering. This project, more than most, is an example of the evolution from undergraduate short-term enthusiasm to long-term, and still enthusiastic, productivity. ●

DOWN HOME RESEARCH

Agricultural engineers could possibly be called the first environmentalists. Years before the surge of recent concern over the future results of man's tampering with nature, agricultural engineers had already discovered contour plowing, crop rotation, and fertilization.

For Dave Kendrick, a senior in agricultural engineering, ecology begins at home. Growing up on a large farm near Melvin, Illinois, helped guide Mr. Kendrick's interests into the study of the effects of nitrate pollution.

The study was an analysis of the nitrate content of the water that drained from a field used for the disposal of animal waste compared with the drainage from an abandoned feedlot and other fields. Almost two years were spent taking samples from twenty-one tiles across a one-mile area. In addition, a study of the effects of high nitrate concentrations on fish living in streams in the area was conducted.

The study showed that nitrate content, measured in parts per million, was highest following the spring rains. At this time nitrates leach out of the soil at the fastest rate. The highest concentrations of nitrates came from the abandoned feedlot and the disposal field. Concentrations were lower in the summer because those months produce a lesser flow of water and also because at that time plants absorb and use up the nitrates.

However, the study also showed that measuring nitrates in parts per million, the scale used by environmental control and health agencies, may not be the best scale to use. Measured in pounds per day, the quantity of nitrates dumped into the stream was higher in areas of higher drainage rates. Although concentrations of nitrates from the test disposal field and the abandoned feedlot were higher, the total drainage poured fewer pounds of nitrates into the stream than did other areas.

He also found that although high nitrate levels in water promote the heavy growth of algae, a condition which reduces oxygen in the water and can suffocate fish, a high level of nitrate as such will not harm the fish.

Mr. Kendrick plans to work on a master's degree at UIUC while continuing his work with nitrate pollution. According to him, his undergraduate project only scratched the surface. "It showed me how much more I need to know." ●

HARD-BOILED RESEARCH

Before Joseph Sarmiento and James Mason, seniors in general engineering, started their project, they realized their problem would be a hard one to crack. Their problem was to design a life support system for an egg without a shell. Such a system would allow researchers to view the egg directly at each stage of development and to observe the effects of various experiments and operations on the egg's development.

Their goal was to determine if it is possible for an embryo to survive outside of its natural environment, the eggshell, when placed in a chamber which provides the same environment as the shell in terms of temperature, humidity, and sterility. Because of the laboratory situation, the equipment had to be inexpensive, simple, and compact enough to fit on a laboratory bench.

According to the researchers, the ideal solution to the problem would be a chamber with a set of gloves built into it and a viewing port to observe the embryo. Discarding this as unrealistic, they settled for a modular system, the separate parts being the air filter, the saturator, the air heater, and the chamber itself. The filter takes in air from outside, removes foreign particles, and sterilizes the air. The saturator combines the sterile air with water, and releases it at a relative humidity of 100 percent and a temperature of 92°F. The heater raises the temperature of the saturated air to 99°F, thus achieving both optimal temperature and lowering the relative humidity to an optimal 79 percent. The sterile, saturated, and heated air then flows through the chamber containing the embryo. This chamber is made of plexiglass, for sterilization purposes, and has a flat glass panel at the top to permit microscopic observations. The air then flows on through another filter and out of the chamber.

Whether or not this design will permit the growth of embryos has not yet been proven. However, the design has been carried out, and all the specifications have been met, exactly. ●

WOMEN IN ENGINEERING — IT'S YOUR TURN NOW

A career-counseling conference for high school girls, *Women in Engineering — It's Your Turn Now,* will be sponsored by the UIUC College of Engineering and the student branch of the Society of Women Engineers on October 29 and 30. The conference will consist of panel discussions, talks, and opportunities for face-to-face contact between high school girls interested in engineering and women engineering students, recent graduates, and practicing women engineers. Keynoting the conference will be Dr. Betsy Ancker-Johnson, assistant secretary of commerce for science and technology. For further information on attending the conference, write Women in Engineering, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

LONG-WINDED RESEARCH

Unfortunately, as the Dorothys of the country will testify, falling houses damage much more than wicked witches. Those homes most susceptible to damage from Kansas twisters, and all other midwestern winds over sixty-five miles per hour, are the mobile homes.

Last summer Barbara Boslego, then a junior in civil engineering at UIUC, proposed a research project to study the effects of wind forces on mobile homes: the means of anchoring mobile homes to resist wind forces, the code requirements and suggestions for anchorage, and the manufacturers' and owners' compliance with codes and recommendations. Because of the short time available for the study, she conducted her literature search while designing her research. She contacted the mobile home manufacturers' association, individual mobile home manufacturers, and local operators.

In midsummer, just as she was about to begin testing a model mobile home in a UIUC wind tunnel, she made a discovery that occasionally plagues even the most thorough researcher. Her search of relevant technical literature uncovered a project at another university that had conducted similar research, using almost the same experiment that she had planned.

"Any time a wind comes up on these prairies, they roll a few over." A program to educate mobile home owners on ways to prevent the type of wind damage pictured above has been assembled by a UIUC researcher in civil engineering.

Rather than scrap an entire summer of work, Miss Boslego decided to turn her research into an educational program. She finished the summer by collecting slides of wind damage to mobile homes and wrote a script on the means of protecting them. Her collected slides and accompanying script are now shown to mobile home owners, park operators, and dealers across the country.

Miss Boslego, now a graduate, is very realistic about the results of her project. She says it gave her an insight into the duplication of research efforts which occurs due to lack of communication between interested parties and the time lag between research and application of new knowledge.

While not completing the type of project she had anticipated, Miss Boslego did use an experience of real-world frustration to her advantage. Her project also helped to close the communication gap that was dramatized by her research. ●

ENGINEERING SALARIES AND EMPLOYMENT UP

Could it have been a result of their undergraduate research projects in engineering? Mrs. Pauline V. Chapman, placement director for the College of Engineering, has announced a jump in both pay and employment rates for June graduates from the UIUC College of Engineering.

The average salary for the UIUC June graduate was $933 a month. This is the highest rate ever, $29 per month more than in June of 1972. In addition, only 8 percent of the June graduates were still seeking employment at the time of the survey, as compared with 14 percent a year ago. Fifty-two percent of this year's graduates went directly to jobs, compared with 33 percent last June. The remainder are divided between travel, military service, and graduate study. ●

PEOPLE AND PLACES

Daniel C. Drucker, dean of the College of Engineering, has been elected the 93rd president of the American Society of Mechanical Engineers. Dean Drucker is a fellow in the society, has held many offices, and has served as technical editor of the *Journal of Applied Mechanics.*

Professor **Chester P. Siess** has succeeded Professor **Nathan M. Newmark** as the head of the UIUC Department of Civil Engineering. Professor Newmark, who has been head of the department since 1956, will continue on the civil engineering faculty and will also remain a member of the UIUC Center for Advanced Study. Professor Seiss has been a member of the UIUC faculty since 1941.

Professor **George H. Miley** of the Department of Electrical Engineering and the Nuclear Engineering Program has been elected president of the UIUC section of the American Society for Engineering Education.

Carl S. Larson, associate professor of mechanical engineering, has been named assistant dean of the College of Engineering. Assistant Dean **David R. Opperman** has assumed the duties of director of placement and cooperative education, succeeding Pauline V. Chapman.

Professor **Bruce A. Hertig** of the Department of Mechanical and Industrial Engineering, the Department of Physiology, and the director of the Laboratory for Ergonomics Research has been elected treasurer of the American Industrial Hygiene Association.

John Bardeen, professor of physics and of electrical engineering, was named "Illinoisan of the Year" by the Illinois News Broadcasters Association.

Professor **David Pines** of the Department of Physics has been elected to the National Academy of Sciences. He is one of ninety-five newly elected members of the organization and the twentieth member from the UIUC faculty.

Gerald P. Wirtz, associate professor of ceramic engineering, has been named to the half-time revolving assistant deanship in the College of Engineering. The position was established in 1969 to provide additional student and department contacts for the associate dean's office.

Paul E. Parker, former assistant to the dean of engineering at Agricultural and Technical College of North Carolina, has been named assistant dean of the College of Engineering.

Professor **Ven Te Chow** of the Department of Civil Engineering has been elected chairman of the Robert E. Horton Memorial Fund, fellow of the American Geophysical Union, and fellow of the American Academy of Mechanics. ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 15, NO. 2, OCTOBER 1973

inside outlook:

QUICK-CURING OF CEMENT
WATER QUALITY CONFERENCES
PULSE PROPAGATION IN CURVED BEAMS
DYNAMICS OF HIGHWAY BRIDGES
SCANNING ELECTRON MICROSCOPE FACILITY

A HARD LOOK AT CONCRETE

If cement could be made to harden more quickly, indelible records of the feet of dogs and small children would be far less frequent. Without regard for future generations of wet cement stompers, three researchers from the UIUC Department of Civil Engineering have found a way to treat cement so it acquires in ten minutes the strength it would take seven days of normal curing to attain.

Professors Francis Young and Dick Berger and undergraduate John Breese have studied the effect of carbon dioxide on portland cement, and also on tricalcium silicate and dicalcium silicate, which are the chemical compounds that make up portland cement. The fact that carbon dioxide can work to speed the hardening process had been previously established. These researchers went about discovering the mechanisms of the curing process, the efficiency of the process, and the chemistry of the process by varying the experimental parameters.

To test the reaction, they mixed pure concrete compounds with varying amounts of water and compacted them under pressure to make small cylindrical specimens. These specimens were exposed to carbon dioxide under pressure varying from one to four atmospheres. They found that the optimum amount of water with this procedure was only one-fifth of what is required to make normal concrete. They also found that increased pressure increased the speed of the reaction.

Their most significant findings, however, concerned the chemistry of the carbon dioxide reaction. Portland cement reacts with water to form an alkaline solution of calcium. The researchers thought that precipitation of calcium carbonate from this solution — when treated with carbon dioxide — would act to bind the cement grains together and provide strength. However, it was found that carbon dioxide promoted a vigorous reaction between the calcium silicates in the cement and the water. The reaction occurs several hundred times faster than usual and is essentially complete in ten minutes. A slower and more complex reaction with carbon dioxide then continues, promoting further hardening.

Recent work has shown that the use of high pressures, up to 250 atmospheres, has resulted in similar reactions of other calcium silicates that are not normally considered reactive towards water.

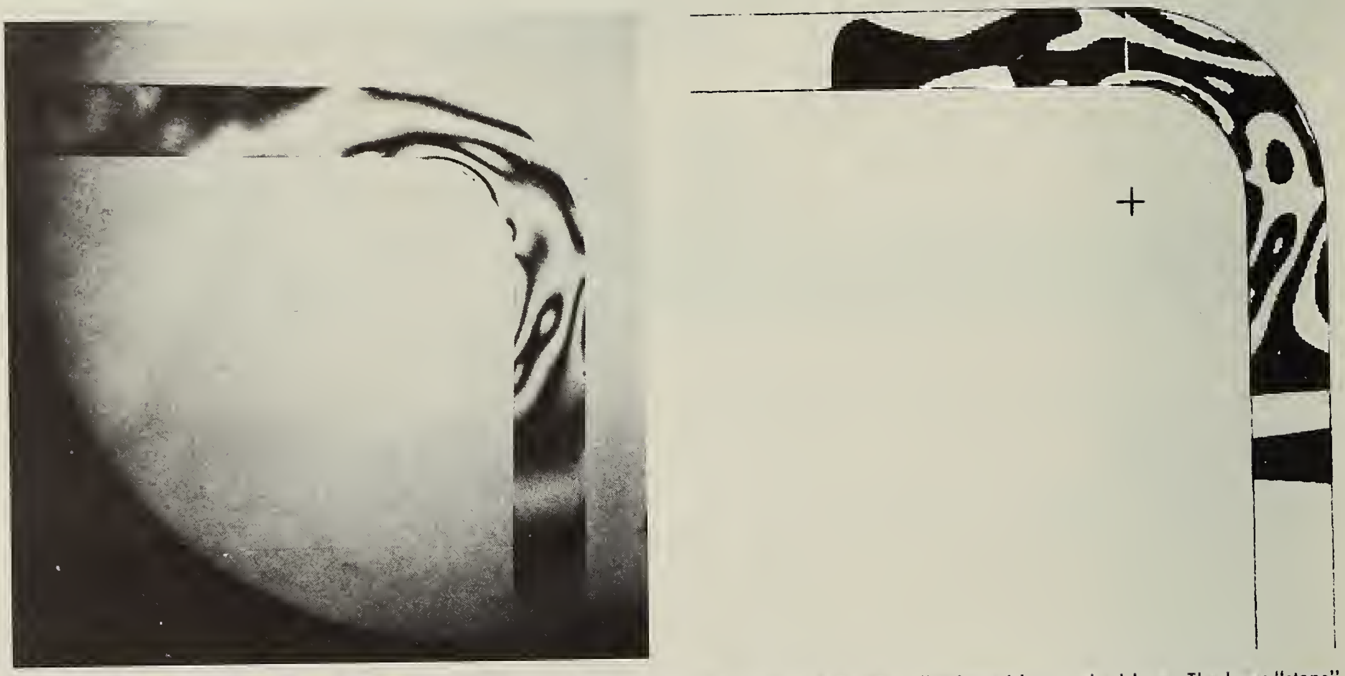
This rapid reaction holds promise for future applications. The production of precast concrete products could be vastly speeded up by this method of curing. It also opens the possibility of successfully using slags from the steel and aluminum industries, and other industrial by-products, to make concrete. The study has also added to the general understanding of the chemical process involved in the normal hardening of cement. All in all the study went a long way towards providing more concrete facts about cement. ●

WATER QUALITY, PAST AND FUTURE

A new publication, *Proceedings of the Fifteenth Water Quality Conference, Organic Matter in Water Supplies: Occurrence, Significance, and Control,* is a reference of what is known and what is unknown about organic contaminants in drinking water. Copies are available for $6.50 from Engineering Publications, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

The Sixteenth Water Quality Conference, carrying the theme "Trace Metals in Water Supplies: Occurrence, Significance, and Control," will be held at UIUC on February 12 and 13, 1974. It will be jointly sponsored by the American Water Works Association, the Illinois Environmental Protection Agency, and the UIUC Department of Civil Engineering.

Further information on the sixteenth annual conference may be obtained from Professor John T. O'Connor, 3221 Civil Engineering Building, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●



A projectile fired into a photoelastic model of a curved beam produces fringes when the model is illuminated by a pulsed laser. The laser "stops" the motion of these fringes and they are recorded photographically (left). The remarkable agreement between the photograph and the theoretical pattern (right) indicates the applicability of a theory developed by Illinois engineers.

BEAMING WITH SUCCESS

If a violin string is plucked near one end, a wave will move along the string and be reflected at the other end. There is a well-known elementary theory which explains the propagation of waves in a string. In a similar way, a straight bar or beam, if struck from the side, will undergo wavelike motions, but the theory for a beam is somewhat more complex than that for a string. The theory for a beam becomes even more complex if the beam is bent into the shape of a circular arch.

Professor James W. Phillips of the Department of Theoretical and Applied Mechanics has found a technique for solving the equations governing the propagation of short waves, or pulses, in curved beams. He and Francis B. Crowley III have found good agreement between their theoretical predictions and experimental data. Experimental pulses were generated by lead pellets fired to strike ten-inch photoelastic model beams from an air rifle. When a ruby laser illuminated the pulsing model, isochromatic fringes, visible wave motions, were produced which were recorded photographically.

Professor Phillips is now tackling the general dynamic equations for a helical coil (of which the curved beam is a special case) under a grant from the National Science Foundation. The results of the new project should shed some light on the design of a superconducting helical coil presently under investigation by Argonne National Laboratory for use in a heavy-ion accelerator. Hopefully the theory will again be proved upon pulses by plucky researchers. ●

e) NONE OF THE ABOVE

Helping students determine their qualifications for engineering studies is the goal of the National Engineering Aptitude Test for high school students in grades nine through twelve. The test will be conducted by the Junior Engineering Technical Society, which has state headquarters at the University of Illinois at Urbana-Champaign. The test, which measures verbal, numerical, scientific, and mechanical comprehension, supplements school testing programs. Students receive personal reports of results.

Application deadline for the test, to be administered February 16 at UIUC, is December 1. Charge is $3. Applications and information are available from Professor David C. O'Bryant, 214 Transportation Building, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

A BRIDGED VERSION

Over troubled waters, or regular little creeks, it's nice to know that a bridge that starts you out will take you to the other side. Civil engineers at UIUC, under the direction of Professor W. H. Walker, are currently studying the dynamics of highway bridges; how much load they can take, and for how long. Their goal is to build a base of data that will guide the future construction of highway bridges.

Their approach uses two aspects of the study of the dynamic response of highway bridges. The first is the actual study of the effects of dynamic and static loads and the

The microscapes of the UIUC Center for Electran Microscopy can be applied to many diverse areas of study. These scanning electron micrascope pictures are of a transistor (left, actual size 0.01 inch), an incandescent light bulb filament (0.5 inch), and for hayfever sufferers, Aster pollen (0.001 inch).

stresses they produce on the bridges. To do this they are concentrating on short- and medium-span bridges, with lengths varying from 20 to 100 feet, whose traffic is mainly one directional and concentrated in the right lane. The prototype of this is the small interstate highway bridge.

Working on I-80, near Rock Island, Illinois, they loaded and drove trucks over the bridges, and measured the stress responses with electric resistance strain gauges. Since the beams holding the bridge are not perfectly rigid, nonuniform deflections occur across the loaded bridge depending on the speed of the vehicle, the weight of the load, and the length of the truck crossing the bridge. The sensitive gauges were able to record strains corresponding to stress as low as 300 pounds per square inch. The information resulting from the tests on bridges with steel beams and concrete decks shows that, barring defects in the beams, the life expectancy of these bridges is probably longer than the life expectancy of the highways leading to them. This information will be used to aid in the development of specific construction specifications for future bridges.

The second part of the study involves the psychological aspects of bridges. The comfort of the user or pedestrian is most important in this area. The researchers, again headed by Professor Walker, found that most of the vibrations felt by bridge users are mainly influenced not by the characteristics of the bridges themselves, but by the condition of the road surface over the bridge which induces vibrations in both the vehicles and the bridge.

Besides adding to the store of knowledge on bridges, this information becomes significant when viewed in relation to the pressure to allow larger and heavier transportation vehicles on highways. As to whether more traffic with larger and heavier vehicles would significantly decrease their life expectancy, Professor Walker said he will cross that bridge when he comes to it. ●

THE BETTER TO SEE WITH

At the UIUC Materials Research Laboratory, they've found that the best way to see small is to think big. Over the summer, MRL and the Center for Electron Microscopy in Bevier Hall have expanded their facilities to include the best equipment for scanning and transmission electron microscopy available.

Now in use is a new 200 kV transmission electron microscope with scanning electron microscopy facilities. This instrument is able to scan and photograph specimens, magnify them more than a thousand times, and send back a picture to the camera and the eye by monitoring electrons which are bounced off the specimen.

Its transmission facilities make it possible to gather information in more detail than ever possible before on the internal, as well as the external, structure of the specimen. With the 200 kV transmitting electron microscope, it is possible to "see through" samples 100,000ths of a centimeter thick. This, although it may not sound impressive, is a few thousand layers thick in terms of atomic structure, and surpasses the abilities of the previous instruments two to three times.

In addition, a new electron microprobe has been added to the facilities. The microprobe has quantitative as well as qualitative capabilities, and is another important addition to the range of equipment.

In total, these instruments will make analysis of the microstructure of materials easier and more accurate, adding concrete data useful to performance design for aerospace, nuclear, and high-temperature research. The new instruments will be used for teaching as well as research, and will be available to engineering faculty and students. Not the least of the instruments' teaching potential is the demonstration to students that their large and confusing megaversity is, after all, a conglomeration of comprehensible submicroscopic particles. ●

PEOPLE AND PLACES

The second annual L. E. Grinter Distinguished Service Award has been presented to Dean Emeritus **W. L. Everitt** by the Engineers' Council for Professional Development. The award recognizes his long career of service to the engineering profession.

Professor **Vincent J. McDonald** of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign has received the C. A. Hogentogler Award for 1973 from the American Society for Testing and Materials.

For contributions and leadership in aviation, Professor **Helmut H. Korst**, head of the Department of Mechanical and Industrial Engineering, has been honored by the American Institute of Aeronautics and Astronautics with election as a fellow of the institute.

John B. Stall, engineer in charge of surface water research, has been named head of the hydrology section at the Illinois State Water Survey, succeeding **H. F. Smith**, who retired September first. Stall has been on the survey staff since 1946.

Professor **Shao-Lee Soo** of the UIUC Department of Mechanical and Industrial Engineering has been named a fellow of the American Society of Mechanical Engineers. This grade of membership is conferred upon a member who has made significant achievements in the field of engineering.

Donald L. Bitzer, director of the Computer-based Education Research Laboratory, professor of electrical engineering and research professor in the Coordinated Science Laboratory, has received the 1973 Bobby C. Connelly Memorial Award of the Miami Valley Computer Association of Dayton, Ohio, for "achievement in data processing."

Professor **Ralph L. Cook** of the Department of Ceramic Engineering has received the Arthur Frederick Greaves-Walker Award of the National Institute of Ceramic Engineers. The award is made annually to members "who have rendered outstanding service to the ceramic engineering profession." ●

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engineering outlook

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COLLEGE OF ENGINEERING
VOL. 15, NO. 3, NOVEMBER 1973

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AT URBANA-CHAMPAIGN

inside outlook:

FISSION AND FUSION REACTORS
COOLING UNDERGROUND POWER CABLES
VARIABLE ANTIDIVE SUSPENSION FOR VEHICLES
STUDY ON ENGINEERING EDUCATION

POWER TO THE PEOPLE

With "brownouts" and energy "crises" taking much of the front-page attention of the nation, it may seem impractical to talk of an unlimited supply of power. But research is pointing the way toward an almost inexhaustible supply of nuclear energy, albeit in the distant future.

There are two methods of producing it. Fission reactors use neutrons as atomic bullets to split heavier elements and release tremendous amounts of energy. Fusion reactors use extremely high temperatures and pressures to join lighter elements and release energy. Present-day fission reactors could supply us with power for decades; the fast breeder variety currently under development could produce both energy and fuel which would supply nearly unlimited amounts of energy. Wouldn't these be preferable to fusion reactors which involve containment of a plasma with a temperature approaching that of a miniature sun?

Research being conducted at the University of Illinois at Urbana-Champaign indicates that fusion reactors may eventually become competitive with, perhaps superior to, fission reactors. G. H. Miley, professor of nuclear engineering and of electrical engineering at UIUC, cites three reasons.

First, fission produces a lot of long-lasting, radioactive waste. The handling and disposal of this by-product is becoming increasingly costly. On the other hand, although fusion involves a radioactive element (tritium), this is a form of hydrogen which can be used to fuel other fusion reactors.

Second, fusion reactors are inherently safe. Nuclear excursions cannot occur through their use, although fusion reactions require temperatures in the millions of degrees and pressures of many atmospheres. Even if all the fuel in the reactor were burned at once, the resulting energy release would be minor.

Perhaps the most potent argument for the development of fusion reactors is their high efficiency potential. Current fission reactors use steam-powered turbines. Heat from the reactor is passed through an elaborate heat-exchanger system and then used to boil water. The steam produced drives a turbine connected to a generator. Less than 45 percent of the heat energy is converted to electricity; 55 to 65 percent is lost to the environment as heat — thermal pollution.

Fusion, however, is adaptable to methods which can convert the energy directly to electricity, by-passing steam. Conversion efficiencies of 60 to 80 percent may be possible, cutting waste energy by at least half. The core of a fusion reactor is a superheated plasma with much of its energy in the form of fast-moving charged particles which can be maneuvered by electromagnetic fields. Several methods for converting this hot cloud of electric charges directly into electricity have been proposed.

In one method charged particles are allowed to escape from their magnetic bottle. Other magnetic fields separate and direct the particles onto high-voltage collector plates. Then the voltages of the plates are equalized and combined. The resulting direct-current electricity is transmitted to the customer. Experiments using an accelerator to produce charged particles have shown that this method can be 70 to 90 percent efficient.

By the 1980s a deuterium and tritium (D-T) fusion reactor which produces as much power as it uses should be available for research. A commercial D-T plant may be operating by the year 2000. Eventually other, improved fuels, such as deuterium-helium (D-He^3), may result in the ultimate goal of high efficiency and negligible pollution. Hopefully we can look forward to a twenty-first century in which cheap, plentiful, and nonpolluting energy will be taken for granted — a vision made possible by fusion. ●

THE CURRENT UNDERGROUND

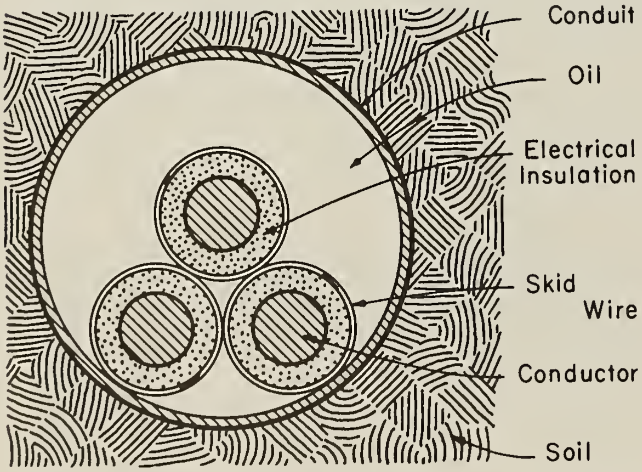
Taking in the sights from sea to shining sea nowadays often involves going from pole to pole — from electric pole to electric pole, that is. Moreover, those lines looping above the landscape are costly as well as unsightly.

Especially in urban areas, congestion, land prices, and visual pollution are getting worse. All of these things pointed to the replacement of aboveground power lines with underground cables, as a partial solution to the problems. They are less expensive and are not a glaring interruption of the scenery. But the establishment of these underground lines has posed some serious problems of its own. Chief among them is the generation of excess heat buildup in the power lines, due to the poor heat transfer.

Finding the best way to cool the system is the subject of a project currently being conducted at the University of Illinois at Urbana-Champaign, led by John C. Chato, professor of mechanical engineering and bioengineering. Chief sponsor is the Electric Power Research Institute, and there are also major contributions from the U.S. Department of the Interior and UIUC.

Carrying the current underground are pipes called conduits, each conduit holding three cables. Each cable is made up of heavy copper wire and a thick insulation of oily paper. "Skid wire," so called because it helps the cables to be pulled through the conduit, is twined around each cable. The considerable heat generated by the flow of current through the conduit must be transferred from the cables to the air surrounding them. An excessive buildup of heat would ruin the insulation and cause short-circuiting and severe damage in the system.

This problem was first encountered in urban areas when increasing electrical demand, coupled with summer temperatures, caused existing cables to overheat. In some cases the heating was so severe that it was necessary to flood adjacent conduits with cooling water in order to prevent breakdown of the electrical cables. The problem of dissipating extra heat had become serious.



Mechanical engineers at UIUC are studying heat flow in underground electric cables like these to increase their current-carrying capacity.

Professor Chato and the three graduate student assistants working with him believe that circulating a nonconducting oil through the conduits would be one of the best methods of cooling. The configuration of the cables as well as the speed and patterns of oil circulation are important considerations. In addition, methods of pumping the oil through the conduit and then removing the heat from it pose significant problems.

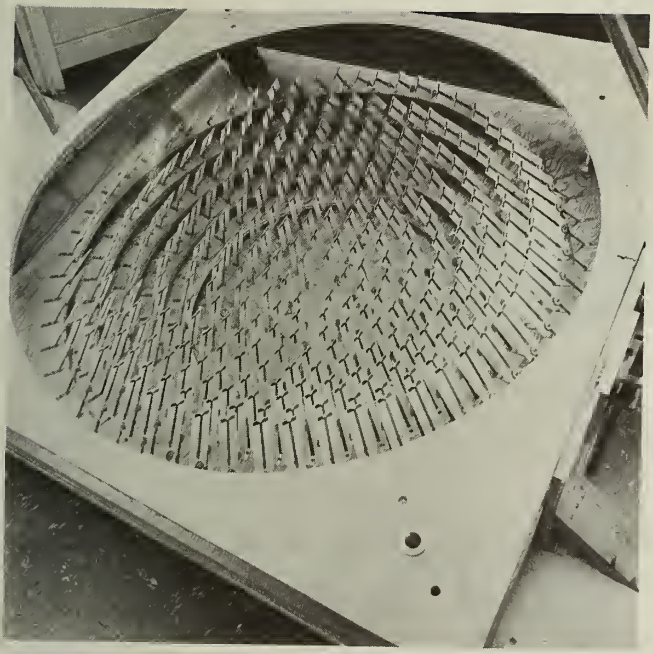
The position of the cables inside the conduit is an important factor in the effectiveness of oil as a coolant for overheated cables. If the three cables are lying against each other, pyramid style, on the bottom of the conduit, the oil will flow over them, cooling the upper surfaces of the cables but not effectively cooling the cable surfaces on the bottom of the conduit. Chato believes one solution might be to make the skid wire instrumental in the circulating of the oil beneath the cables.

Since the maximum temperature of the hot oil would be 160°F, air or water at any temperature below that could be used to cool it. If there is a nearby water source, such as a stream, the oil could be piped through it to remove the heat; but in most cases such a water supply is not available.

The use of a heat exchanger into which oil flows while a fan blows in outside air is possible, but more expensive to operate than a water-cooling system. The most expensive method is the refrigeration method, which would actually generate more heat into the atmosphere than it removed from the oil.

Chato believes that air, and the pressure and density differences of hot and cold oil, could be used by employing natural convection. A column would be built, through the center of which the hot oil would rise. As the oil gradually cooled, its increased density would cause it to flow down an outer passage built around the central one, to be recirculated through the system. The height of the column would depend on how long the oil would take to cool and the rate at which it was circulating. This system, the most economical of all the possibilities, would be self-perpetuating; but the problem with it is how it would be started up again if it were stopped — yet another area for the UIUC team to explore.

Chato expects research to be completed by December 1975. Until then the heat's on to get the heat off of underground cables. ●



This unusual antenna produces a scanned beam of RF radiation free of coma aberrations. It is used in electromagnetics research at UIUC.

KNOWS DIVE

A group of students at the University of Illinois at Urbana-Champaign is studying diving. Their chief problem is figuring out how to get rid of it cheaply. "Dive" is the term used for the downward pitch of the front end of an automobile when the brakes are applied. In quick-stop situations, this can result in a near-scraping of the front bumper on the road. One answer to this problem is a variable antidive front suspension system.

As a matter of fact, this system is currently used in some high-priced European autos. But the system and its maintenance are very expensive. The goal of the Illinois project is the development of a system which will not significantly raise the price of cars and which will be easy to service.

The project, under the direction of Professor L. D. Metz of the UIUC Department of General Engineering and sponsored by the Ford Motor Company Car Research Division, is being carried out by three senior undergraduates. The study is being undertaken on a theoretical level. The students have as a final goal the development of a math model which can be used to design an inexpensive system. After developing a model, the students will use a computer to simulate a working vehicle and thus "test" the system.

The problem is more complicated than it may seem. Connected to the front axle of a car are four A-arms, so called because of their shape: each arm is made up of two bars forming an acute angle, with a supportive bar in between. Both an upper and a lower A-arm are attached to each front wheel. When the brakes are applied, some of the weight of the car is transferred to the front end, causing it to dive, or dip.

The angle of inclination of the pivot axis of the upper A-arm is usually fixed with respect to the ground. This results in a fixed amount of antidive force, and the rate of deceleration is the sole determinant of the amount of dive. The quicker the stop, the more severe the dive. In a variable antidive front suspension system, however, the angle of the upper A-arm is able to change. There is much less dive in this situation, since the changing angle compensates for varying rates of deceleration.

But there is another problem. For reasons which are still being argued in engineering circles, an antidive front suspension system makes for a generally harsher, rougher ride. The students hope that the variable system they come up with will provide potential for considerable antidive force and, at the same time, allow for a smooth ride under normal operating conditions. By combining the best of both, they hope to help the American motorist stop short without having to take a dive. ●

MAKING PARALLEL LINES INTERSECT

Engineers and social scientists in academia have for a long time pursued their respective occupations without having much contact with one another. Many times no connection was ever made between technology and the social sciences; problems and advancements in one area seemed to be totally unrelated to those in the other area.

Beginning in the 1972-73 school year, the University of Illinois at Urbana-Champaign put into operation a special experiment designed to incorporate into engineering education the ramifications and considerations of the various areas of the social sciences and humanities. This experiment was proposed in response to a request by the Alfred P. Sloan Foundation to twenty universities that they conduct two-year investigations into a broader based, more interdisciplinary approach to engineering education. The proposals of eight institutions, including that of the University of Illinois, were accepted, and UIUC received a grant of $319,000 to conduct its work.

Planning began in the summer of 1972, when twelve professors in the fields of engineering, social science, and humanities set up a seminar to turn the proposal into a workable project. New members joined the core group in that first fall semester, making a total of twenty-four participants.

With the technology of energy as their main thrust, the group attempted to build mathematical models of the energy system, incorporating human and social elements.

This was a real challenge, and precipitated discussions which helped them to understand each other and their value systems better. The group also worked together on a questionnaire, and conducted a field study in the community to get ideas on value systems and priorities of people regarding energy usage. The frequent in-depth discussions of the participants on the results of these two activities and how to interpret them culminated in the appreciation and respect of the participants of each field for the opinions and values of the other fields. From this point the professors moved out into their classrooms in the fall of 1972 to include this broadened sense of values in their approaches to their respective subjects.

Since then, the participation has been kept consistently at twenty to twenty-five professors, who continue to meet once a week to enlighten each other on their varying areas of concentration. The group deals not only with energy problems, but also with ways more guidance in social science areas can be given to engineering students.

One interesting by-product of this Sloan program has been the doors it has opened for the beginnings of interdisciplinary research by faculty from engineering, social science, and humanities. Professors in these fields, having worked together closely through the program, have found areas of common interest, and are beginning to conceive of research projects on their common concerns. As heads get together, there may emerge better answers to some old problems.

In a very real sense, parallel lines are beginning to intersect. Perhaps X will continue to mark the spots of cross-discipline understanding, even after the Sloan program comes to an official close in 1974. ●

PEOPLE AND PLACES

Professor **Harry G. Drickamer** of the UIUC Department of Chemical Engineering is the 1974 winner of the American Chemical Society's $5,000 Irving Langmuir Award in Chemical Physics.

Professor **Ralph B. Peck** of the UIUC Department of Civil Engineering has been decorated by the Department of the Army with the Outstanding Civilian Service Award for his contributions in the field of soil mechanics.

Benjamin A. Jones, Jr., professor of agricultural engineering at UIUC, has been appointed associate director of the Illinois Agricultural Experiment Station at the University of Illinois at Urbana-Champaign.

Professor **Earl J. Eckel**, of the UIUC Department of Metallurgy and Mining Engineering, has received the Albert Easton White Distinguished Teacher Award of the American Society for Metals. ●

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inside outlook:

ROUTING WASTE COLLECTION VEHICLES
METEOR RADAR SYSTEM
DYNAMIC GAME THEORY RESEARCH
FARM EQUIPMENT ANALYSIS

GETTING TO THE PROBLEM OF THE ROUTE

At first glance, there seems to be little relationship between Baltic parades, Chinese mailmen, and New York trash collectors. But a researcher at the University of Illinois at Urbana-Champaign is drawing on the first two to provide a solution for a problem involving the third.

Leonard Euler, an eighteenth-century Swiss mathematician, tackled the first problem by attempting to direct a parade over a particular route in the Baltic seaport of Konigsburg which crossed each of the city's seven bridges only once. In 1961, M. Kwan developed a system for routing postmen, still referred to as the "Chinese Postman Problem." While relatively simple in concept, it was cumbersome and time-consuming for computers. Later a mathematical concept developed in 1965 by J. Edmonds was found to be a more efficient computer method for solving the problem.

At UIUC all of this has been put to use, as research by J. C. Liebman, professor of environmental engineering in civil engineering, has resulted in a method of efficiently routing solid waste collection vehicles — garbage trucks. Kwan discovered that by treating all the streets as bridges and all the intersections as islands, he could use Euler's ideas to shed some light on the routing problem. Liebman realized that there were difficulties not dealt with in Kwan's and Edmonds's approach to the situation.

Complications began with the fact that there is more than one garbage truck to be routed; and how best to divide the streets into districts, to be covered by separate trucks, becomes another facet of the search for a solution. The streets themselves are not always cooperative; the plan must take into account that some of them cannot be traveled both ways.

Liebman's project, sponsored by the U.S. Environmental Protection Agency, took two years. The solution he has developed is a set of computer programs to which is added a map of the city for which the routes are being made. The computer can come up with several routes which would cover minimum distances, take the least possible amount of time, and thus maximize efficiency. After this the sanitation engineers of the city will have a new problem — which one to choose.

The variables they have to consider are not part of Liebman's computer programs. For example, U-turns made with a loaded garbage truck may well result in the vehicle toppling with its load; so, the chosen route shouldn't have any. Left turns too, though it is unlikely that they can be eliminated completely, ought to be few. A small number of streets have weight limits which might prohibit travel by garbage trucks. Some roads have so much traffic that it is best to keep travel on them to a minimum, or avoid it altogether. And then, of course, all streets which cross each other don't necessarily intersect — there might be an overpass or underpass.

Even if sanitation engineers have to send the whole plan back to the computer for reworking, the process will be quite fast — and will still result in saving money. And that, after all, is the chief purpose of the project. It is accomplished not only because the routes are more economical than before, but also because the relative ease of the process makes it possible for the routes to change as quickly as the cities change. In testing the solution — some testing was done in Baltimore and Indianapolis — savings ranged from 2 or 3 percent to as high as 15 percent.

The final test of the solution is being carried on now, in a rigorous testing ground — New York City. The State University of New York at Stony Brook is using Liebman's computer programs, along with related work of their own, to develop an efficient routing system for the solid waste collection vehicles of that booming metropolis. The process began last month; if it is successful, it will effectively prove that even the largest cities in the world can have their routes in garbage. ●

THUMB THING TO THINK ABOUT

As the unemployed Dutch boy said walking along the dike, "There must be an opening somewhere." As it happened, he ended up in environmental engineering; but there are more varied opportunities for the alert engineering student today.

The Engineering Placement Office of the University of Illinois at Urbana-Champaign reports a 50 percent increase in recruiters seeking engineering graduates. All graduates found jobs last year, though some had only one or two offers. This year, both midyear and June graduates will have wider choices.

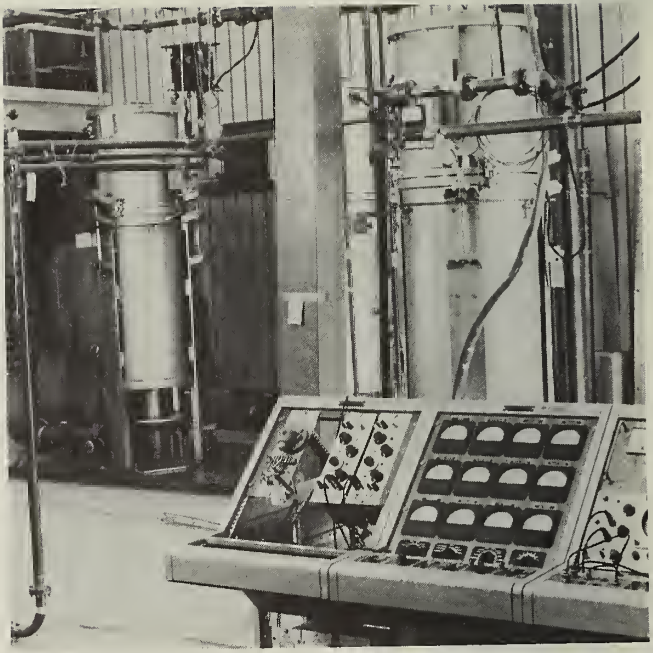
There is currently a shortage of engineers, according to D. R. Opperman, engineering placement director, and opportunities in all engineering fields are great for both men and women. In other words, thumbs up. ●

THE ANSWER IS BLOWIN' IN THE WIND

Researchers at the UIUC Aeronomy Laboratory have hitched their pulses to a star. They're using the natural "skywriting" of shooting stars to get information about the movement of winds fifty to seventy-five miles above the earth.

The information is coming from ionized meteor trails; the radar system being assembled at the University of Illinois at Urbana-Champaign will use the trails to determine wind movements in the high atmosphere. Led by Professors Sidney A. Bowhill and Marvin A. Geller of the Aeronomy Laboratory, Department of Electrical Engineering, the project is being funded by the National Aeronautics and Space Administration. Radar equipment given the University from a discontinued Smithsonian Astrophysical Observatory station is being rebuilt for use in the project.

The radar transmitter is the most powerful one in use for wind studies. It will send out pulses into a northern section of the sky 1,000 miles square and 25 miles deep. Into this area regularly come many thousands of meteors every hour, most about the size of a grain of sand. Those intersected by the earth in its orbit around the sun leave ionized trails behind them as they travel through the atmosphere. When the radar pulses hit the meteor trails, they will bounce off and be detected. The frequency of the reflected pulse will be compared to the frequency of the transmitted pulse to get the velocity of the ionized trail, and thus determine the wind speed at that particular point in the atmosphere. Because of the very high power of the transmitter, about 1,000 wind measurements can be made per hour. Thus the variations in the winds can be quite accurately determined.



The two eight-foot cylinders shown here are the heart of a new meteor winds radar system at the University of Illinois at Urbana-Champaign. The cylinders are tube cavities which are used in the transmission of pulses which are reflected off meteor trails in the upper atmosphere.

Information about how high-altitude winds are behaving will be analyzed by computers to give clues to other natural phenomena. Storms on the sun, for example, are believed to have an effect on the high atmosphere. The field of communication also stands to benefit from the UIUC meteor winds radar system. It will help scientists to understand, and ultimately to predict, the state of the ionosphere, from which AM radio waves reflect when they are broadcast.

In the past, precise wind measurements of the type that will be gathered by this system involved the launching of rockets for research purposes. The cost of frequent launchings limited the number of investigations that were possible. The new UIUC system opens up many new possibilities — the personality of an atmosphere read from a burned-up meteor with a wagging trail. ●

RESEARCH IS THE NAME OF THE GAME

Two engineers at the University of Illinois at Urbana-Champaign are deeply absorbed in playing games. They hope that their games will help people in many fields to make better decisions, win more competitions, and learn more about how people think.

The name of the game is differential (dynamic) game theory; playing are J. B. Cruz, Jr. and M. Simaan. The aim of their research is to arrive at an effective way of modeling and predicting an unlimited number of actions and reactions.

A decision arrived at by two people in a certain competitive situation may be easily predictable; this would be called a "static" game, being based upon one given set of circumstances. But what about decisions of a large number of competitors in an infinite number of diverse situations whose circumstances are constantly changing? That's a problem to be studied in a "dynamic" game context.

One of the important factors in determining outcomes in a dynamic game is the atmosphere within which the decisions are being made. Four strategies in particular are well known and often applicable. The Nash strategy of determining what will be done by the involved parties assumes that the decisions will be made at essentially the same time and such that no one will attempt to deviate or cheat to do better. In that sense it is safe for everybody. The Stackelberg strategy, on the other hand, assumes a leader-follower case in which one of the competitors has in some way an advantage over the others. The Pareto strategy assumes cooperation or agreement between the parties making the decisions; its antithesis is the minimax strategy, in which each decision maker believes that the others want collectively to work against him.

The game theorist tries to develop a set of mathematical equations which can be applied to decision-making problems and can produce a set of conclusions as to what actions will be taken.

If dynamic game theory were applied to a car race, for example, here's how it might work: before the race, mathematical models would have to be made of each car's relationship to every other car in the race with respect to weight, maneuverability, distance separating the cars, and other characteristics. Then the relationship of each car to the physical attributes of the racetrack would have to be determined. After the models of all the relationships had been made, they would be programmed into a small computer in each car, which has a screen on the dashboard where it would be easily visible to the driver. The computer's continuous instructions to the driver as to when and how much to accelerate, for example, or how and where to pass and make turns, would be shown on this screen.

One more thing has to be programmed into the computer before it can begin to hand out its decisions: the strategy being employed. If the Nash strategy is used, then the decisions of all the cars, though in competition, will guarantee that no car would attempt to cheat. The Stackelberg strategy would be the one used if one or two of the cars in the race were more powerful than the others, or had a head start. If each driver were pessimistic enough to believe that the collective power of the other drivers would be employed to make him lose or even destroy him, the minimax strategy would be chosen. And if the Pareto strategy of complete cooperation were used, there wouldn't be a need for a race.

Actually the principles of dynamic game theory probably would not be used in activities such as this. But the potential applications are many in areas such as the decision by firms or individuals of how to distribute resources, cases of competition between companies, and diplomatic negotiations between countries. If there were to be a dam built on a river running through two countries, for example, a Pareto strategy would yield a decision that would be mutually beneficial to both.

To some it may seem presumptuous to use mathematics to study what people will do before they do it. Are people's actions and attitudes so methodically simple to determine and ascertain?

In game theory, it isn't actually the people who are being predicted — it is the situations. In fact this theory helps people to make better decisions in complicated situations. The theorists always assume rationality, and their work with sets of circumstances becomes an optimization problem — what the best decision would be, and the logical choosing of that decision by the sensible decision maker.

Cruz and Simaan plan to continue their game research, finding it involving and satisfying. Certainly their work is up-to-date — one wonders though, in these days of inflation, if $200 for passing GO is really enough. ●

FIELD BETTER FAST

Agricultural engineers have not yet figured out how to hitch a computer to a plow and make it pull, but research at the University of Illinois at Urbana-Champaign indicates that computers can help a farmer with just about everything else. Hoped-for results of a current project are savings for the farmer, maximum energy efficiency, and ultimately, stabilized food prices.

D. R. Hunt of the Department of Agricultural Engineering laid the groundwork several years ago for the project he is now conducting. At that time his studies emphasized the importance to farm efficiency of properly sized field machinery. Now Hunt is working on a computer program that will tell a farmer exactly what size his tractor and machinery system should be, according to his individual needs.

The farmer is required to provide quite a bit of input data for the computer, however, before he can get any kind of answer. He must know which crops he wants to raise, the tillable acreage of the farm, the types of tillage operations he will be doing and the machines he will use to do them (in most cases, attachments to a basic tractor), the rate of return he needs from his investment, and other data. Using Hunt's program, the computer tests different sizes of tractors against the farm's individual characteristics and determines overall cost to the farmer with each. It then chooses the most economical system, informing the farmer which size tractor should be used and why. This allows the farmer to operate his farm at the lowest possible cost to him while making most efficient use of available energy.

In 1970, approximately fifty people were being fed per U.S. farm worker. As this number continues to rise, widespread use of the computer program may be a stabilizing influence in overall food costs. The program is being constantly revamped to provide more and more information, such as optimum replacement times for farm machinery, and the probable number of working days a farmer will have available.

Though this equipment selection model has been developed for farm equipment, similar work could be applied to equipment selection in other fields. And, as is evident from Hunt's research, answers can be found as long as you know what field you're talking about. ●

PEOPLE AND PLACES

For his reports on metal fatigue research, Professor **JoDean Morrow** of the Department of Theoretical and Applied Mechanics at the University of Illinois at Urbana-Champaign has been awarded the Charles B. Dudley Medal by the American Society for Testing and Materials.

UIUC Professor **John C. Chato** was codirector of a nation wide Workshop on Problems of Heat and Mass Transfer in Biotechnology held at the University of Illinois at Urbana-Champaign in September. Fifty engineers, medical doctors, and biologists from all over the United States attended to participate in the discussions.

The National Academy of Sciences has named Professor **Nick Holonyak, Jr.**, of the UIUC Department of Electrical Engineering, to its advisory committee on the USSR and Eastern Europe.

Glenn E. Stout replaces **B. B. Ewing** as director of the Water Resources Center of the University of Illinois at Urbana-Champaign. Ewing is now giving full time to the UIUC Institute for Environmental Studies.

UIUC students have won awards in the nationwide James F. Lincoln Arc Welding Foundation competition for the fourth consecutive year. Fourth prize in the undergraduate division on structures was won by **W. Peter Siems**, Department of General Engineering, under the direction of Professor **B. O. Larson.** Fourth prize in the graduate student division went to **Harinder S. Lamba**, Department of Theoretical and Applied Mechanics; his adviser was Professor **J. Morrow.** ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 15, NO. 5, JANUARY 1974

inside outlook:

DISPERSION OF LEAD PARTICLES FROM VEHICLES
WEAR IN CARBIDE CUTTING TOOLS
SIXTEENTH WATER QUALITY CONFERENCE
OPERATIONS RESEARCH FOR HOSPITAL EFFICIENCY
SCHEDULING AND RESOURCE ALLOCATION REPORT

FOLLOWING THE LEAD

Where does the lead in gasoline go when it is exhausted from moving cars? The answer is still up in the air, but two researchers at the University of Illinois at Urbana-Champaign hope they eventually can be more specific.

Urbana-Champaign happens to be an ideal place to conduct the experiment because there are no industries which emit lead particles into the air. Thus lead in the air can be related to the number of cars on the road and the amount of lead in gasoline.

The reason for using lead in gasoline is to increase octane. The average gallon of gas contains about two grams of lead in the form of the chemical compound tetraethyl lead. (If it were removed, more crude oil would have to be used to produce gasoline of the same octane level.) When the gas is burned as fuel, tiny lead particles are formed which are emitted through the exhaust pipe into the air.

The average lead particle is about 0.25 microns in diameter, invisible, and small enough to be suspended for some time in the wind. Turbulence, or "gustiness" in the wind, however, brings pockets of air in contact with the ground, trees, and other objects, resulting in widespread deposition of the lead particles. Professor J. J. Stukel, Departments of Mechanical and Industrial Engineering and Civil Engineering, and Professor J. L. Hudson, Department of Chemical Engineering, have developed a mathematical model predicting the concentration of lead in the air under various circumstances and are using the information they are currently gathering to revise and perfect it. Their work is part of a heavy-metals project being sponsored by the National Science Foundation.

To collect the data, high-volume samplers have been placed at thirteen stations, ten in Urbana-Champaign's northern rural area and three in the urban area, including one in Stukel's backyard. Filtering units are mounted horizontally on a screen, about three feet off the ground. Below the screen a suction device pulls the air through the filter. The collected lead is measured, and both the total lead concentration and the size distribution of the particles are determined. As information is gathered it is tested against the model and improvements are made.

Since its inception one and a half years ago, the research has centered on the rural area; currently, studies are being concentrated more and more on the urban area. One interesting finding is that the county area around the city has a concentration of lead nearly one-third that of the city. This shows, when compared to the mathematical model, that Urbana-Champaign is not the only source of the lead found in the surrounding rural air.

The investigators hope that their experiments will shed light on two particular related areas of research: the amounts of lead to which people and plants are exposed, and the routes of lead particles from source to final destination.

The experiment will be considered successful when the mathematical model is able to determine, in terms of a time average, the lead concentration in the air under various wind and temperature conditions. From there on, it will be up to other researchers to get the lead out. ●

WEAR TO GO

Researchers at the University of Illinois at Urbana-Champaign are often on the cutting edge of research. As a matter of fact, that's where one of them is right now — studying wear in cutting tools used in heavy industry.

American manufacturers have particular difficulty being competitive with foreign manufacturers. In addition to the cost of labor, the expense of frequent shutdowns for replacing worn-out cutting and shaping tools is high. W. S. Williams of the UIUC Departments of Physics and Ceramic Engineering and graduate researcher G. Baldoni are researching what causes the tools to wear out — and how to slow down the process.

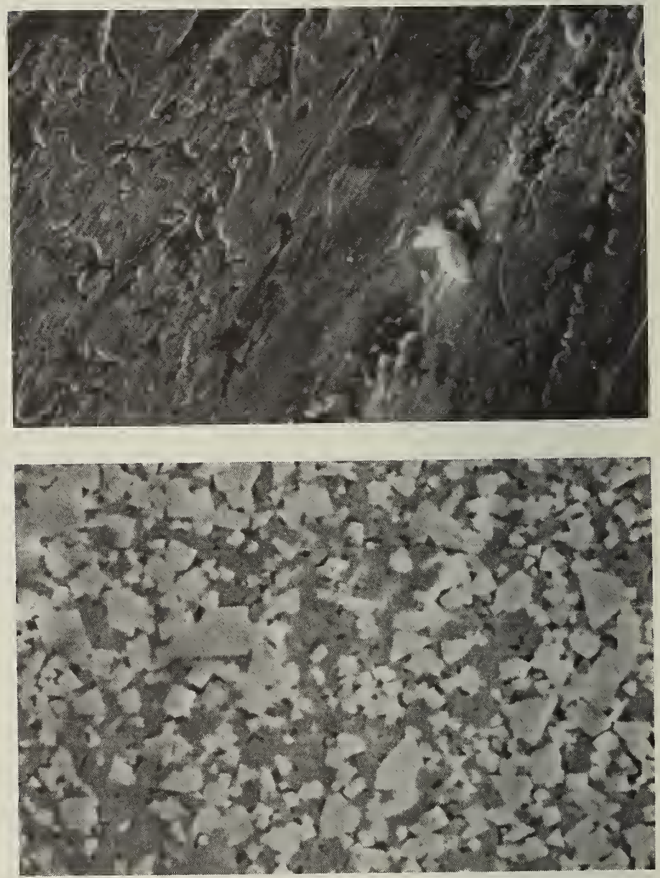
The tools are made of a combination of tungsten carbide, titanium carbide, and tantalum carbide. These materials are in the form of tiny particles, and a bonding agent — nickel or cobalt — is used to cement them together before the materials are made into tools.

When machinery and other products of heavy industry were made of metal alloys such as steel, the cemented carbide cutting tools were hard and strong enough to operate for a respectable length of time before wearing out. Nowadays, however, more durable alloys have been developed for use as the industry's raw material; and progress has brought problems. The stronger metals, combined with a stepped-up rate of production, cause the cutting tools to wear out faster, and they must be replaced more often.

In earlier research, Professor K. J. Trigger of the Department of Mechanical and Industrial Engineering found that the temperature of cemented carbide tools when shaping and cutting is usually between 800° and 1,000° C. Williams hypothesizes that at this temperature the hardness of the tool has decreased to the point of little value in cutting hard metals, though at room temperature the carbides are among the hardest materials known.

One of the properties of these carbides which may play a critical role in the wearing of these tools at high temperatures is plastic deformation. Different from elastic deformation, in which the original shape and position is recoverable, as in a rubber band, plastic deformation denotes a permanent, nonrecoverable change of shape, as in a bent paper clip. The degree of plastic deformation in the cutting tools may be attributable, in part, to the presence of the bonding agents; nickel and cobalt are not as hard as the carbides themselves. But if a harder metal were used as a cementing metal, Williams believes the tool may be too brittle and might shatter in use. And the carbide particles, too, when subjected to high temperatures in operation, undergo severe plastic deformation.

In considering all of the possibilities for solving this heavy industry problem, Williams has many years of his own research on plastic deformation of carbide crystals to draw on. He hopes that through continued, extensive study, manufacturers' problems can be cut down. ●



These photographs, taken by a scanning electron microscope at UIUC, show "before" and "after" states of cemented carbide cutting tools. Below, a section of a new tool, magnified 1,500 times, shows carbide particles bonded together with cobalt. Above, a groove in a worn tool, pictured 300 times its actual size, shows a bright particle of steel which has broken off an item being cut and welded itself onto the cutting tool.

WATER TRACE METALS?

Trace metals in water have become a recurring nightmare for researchers, people in the water supply industry, and those who drink it. Such metals as selenium, chromium, arsenic, mercury, silver, lead, and cadmium may be found in minute quantities in the water of certain areas. As legislation is drafted for the tightening of standards for pure water, there is growing concern among water suppliers for developing ways to detect and remove these trace metals. Health factors influenced by the presence of metal in water are also being examined.

To provide a forum for the discussion of these problems, the University of Illinois at Urbana-Champaign hosts its sixteenth Water Quality Conference February 12 and 13, 1974, carrying the theme "Trace Metals in Water Supplies: Occurrence, Significance, and Control." Leading authorities in the fields related to the topic will be speaking at the two-day conference. Delivering the first two addresses will be Leland J. McCabe, chief of the Criteria Development Branch of the Water Supply Research Laboratory, National Environmental Research Center, Cincinnati, Ohio, and Gordon G. Robeck, director of the Water Supply Research Laboratory.

The conference will consist of four sessions: 1) Sources, Occurrence, and Standards Pertaining to Trace Metals in Water Supplies; 2) Exposure and Effect of Trace

Metals on Human Health; 3) Monitoring and Removal of Trace Metals in Water Supplies; and 4) Regulation of Trace Metals in Water Supplies.

Further information on the sixteenth annual conference is available from Professor John T. O'Connor, 3221 Civil Engineering Building, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

SCALPEL . . . SUTURE . . . SLIDE RULE

Operations research (often called O.R.) is not always, as the name might imply, a study of surgical procedures conducted in hospitals. But one researcher at the University of Illinois at Urbana-Champaign has been applying her O.R. skills to improving hospital and pharmaceutical efficiency.

In the past, hospital costs were lower, patients fewer, and there was relatively little competition for equipment and services. As costs went up, however, third-party payers — programs and organizations designed to help patients pay medical expenses — came into being. The third-party payers limited the amounts of money they would contribute, and hospitals found that more economizing measures were necessary in their procedures. Equipment had to be carefully delegated, making hospitals more specialized — different institutions handled different ailments. Hospital administrators were faced with an optimization problem: How can money be used to help patients in the best and most efficient way possible? Such considerations as laundry and inventory problems, patients' waiting time, the scheduling of nurses and other personnel for maximum efficiency, and equipment maintenance schedules can be dealt with effectively through operations research.

A current project of Judith S. Liebman, assistant professor of operations research in civil and mechanical engineering, is the solving of some of these problems for some rural and urban areas of Holmes County, Mississippi. An acute hypertension problem was discovered there, and a clinic had been set up for treatment of the disease. When the county conducted a pilot study, it found more people had the disease than could be treated by the clinic, and bottlenecks developed. Liebman's work has been finding the bottlenecks and making the clinic more efficient.

Two procedures, in which she has extensive experience, are effective in accomplishing this. One is queuing theory, the study of waiting lines, and the other is resource allocation, the appropriate and expedient use of available resources. Using these, Liebman is creating a model to ultimately minimize bottlenecks and maximize the number of patients that can have their hypertension kept under control.

Liebman also uses queuing theory to reduce waiting time in outpatient pharmacies by coordinating peak crowded times with the scheduling of a proportionate number of the pharmacy's staff. This helps to solve the problems without incurring extra expense.

Across-the-board shortages have shown us that everything spendable is expendable. Operations research is pointing the way toward the best ways of spending — with the goal of bettering human life. ●

NOW TRY TO WORK THAT WAY

Like the man who keeps his nose to the grindstone, his shoulder to the wheel, his ear to the ground, and his eye on the road, the construction planner finds himself in a difficult position. He is given a project he did not design, limited resources to which he cannot add, a total cost he cannot exceed, a deadline he cannot extend, and then told to prepare a feasible project schedule.

If he is up-to-date, the planner may use one of several mathematical techniques to help him out of his dilemma. But each of the current techniques has its own limitations. Minimum duration models can determine the shortest possible project schedule, but they often fail to resolve space or resource conflicts. Two operators cannot perform two different jobs with the same crane at the same time. Another technique, resource leveling, uses nearly equal amounts of men and equipment for each project period (week or month), but these often extend the life of the project and increase overhead costs. A third method, time-cost tradeoff models, tries to balance the need to meet the deadline against the cost of a weekly payroll. These models work well if there are no space limitations or resource conflicts; however, conflicts do appear and the cost of moving equipment in and out of the project is generally ignored.

The shortcomings of these techniques leave the planner in somewhat of a bind. But research at the University of Illinois at Urbana-Champaign may provide the planner with an answer. One means of finding the "best" solution (a solution that avoids conflicts and meets the deadline at the lowest cost) to resource allocation and scheduling is to examine all possible solutions and then select the least expensive. On a project of any size, though, there could be an exceedingly large number of ways to schedule and allocate resources.

UIUC graduate student A. A. Chaker has proposed a branch and bound algorithm that overcomes this difficulty by dividing all possible solutions into a manageable number of groups and determining the least costly group of solutions. The algorithm then divides this group into smaller groups, repeating the process until it zeroes in on the one least costly solution that meets time requirements and avoids conflicts.

The particular beauty of Chaker's approach is that, with constraints specified, space conflicts (the number of bulldozers that can fit in an excavation of given size) and resource conflicts (three back hoes cannot be scheduled in four locations simultaneously) are resolved giving a realistic, minimum-cost schedule.

The results of Chaker's work are described in Construction Research Series Report Number 17, "Optimal Scheduling and Resource Allocation in Project Networks." This report presents a complete definition of the algorithm, a discussion of the steps involved in the solution process, and some computational experience in solving this problem using a computer program. CRS No. 17 is available from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801 at a cost of $4.00. Remittance must accompany all orders under $5.00. ●

PEOPLE AND PLACES

Four engineers who graduated from the University of Illinois at Urbana-Champaign were given Distinguished Alumnus Awards by the Mechanical and Industrial Engineering Alumni Association. They are **Alwin Schaller** (1907), **Harold A. Schwanbeck** (1933), **Richard B. Engdahl** (1938), and **Richard E. McGrath** (1948).

Four professors in the UIUC Department of Electrical Engineering have been elected fellows in the Institute of Electrical and Electronics Engineers. **John D. Dyson** was named for contributions to the development of log-spiral antennas; **Oscar L. Gaddy** for contributions to the development and understanding of fast-response time detectors in both visible and infrared regions of the spectrum; **Charles D. Hendricks** for contributions to electric propulsion and small particle technology; and **Benjamin C. Kuo** for contributions to control system theory and practice. ●

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AT URBANA-CHAMPAIGN

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VOL. 15, NO. 6, FEBRUARY 1974

inside outlook:

EFFECTS OF NOISE ON INNER EAR
ENGINEERING OPEN HOUSE
FIBER-REINFORCED CONCRETE FOR TUNNELS
A CHAIN THAT PUSHES
ENERGY RESEARCH GROUP

EH?

"Hear today, gone tomorrow" might mean deafness is just around the corner if people take their ears — and their hearing — for granted. Professor Harlow W. Ades, Department of Physiology and Biophysics and of Electrical Engineering, has been researching various aspects of the ear for thirty-five years. Currently he is studying the effects of noise on the cochlea, the coiled portion of the inner ear which plays a major role in the hearing process.

The inner ear has two main parts. One part, the semicircular canals, has nothing to do with hearing but controls balance. The other is the cochlea. The eardrum is the organ chiefly responsible for delivering vibrations from the outer ear through the three small bones of the middle ear to the inner ear. The inner ear contains a fluid which is used as a medium for the transmission of sound vibrations. The tiny "hair cells" of the cochlea, so called because they have hairlike cilia, transform the waves in the fluids into nerve impulses. In general, the deterioration of hearing can be measured by the number of damaged hair cells in the ear. Different types and volumes of sound produce different vibrations of the fluid, and if they are too violent, they can kill the sensitive hair cells.

It is difficult to determine the degree of hearing loss. The studies of Ades and his colleagues are directed toward discovering at what decibel level the normal hearing organ is damaged. Decibels (dB) are the standard of measurement for sound. A jump of three decibels is equivalent to doubling the sound; a decrease of three, to halving it. Thus 63 dB is twice as loud as 60 dB; and 120 dB is more than a billion times louder than 60 dB.

There are really two kinds of damage: the actual mechanical damage of the hair cells or other parts of the ear due to severe levels of noise, and the eventual metabolic change that may result from prolonged exposure to lesser levels of sound. Different types of noise affect different parts of the ear. Impulse noise is more damaging to the eardrum; steady noise is bad for the hair cells of the cochlea. However, in a number of working situations, the noise is below the damaging level, which Ades currently believes should mean below 85 dB in cases of eight hours of constant exposure. Noise levels of 70 dB are common. Ordinary offices measure 55 to 60 dB; but the crowded city streets leading to them can reach 95 dB.

Consistent exposure to loudness is the most dangerous situation. Certain occupations have this problem built into the job, such as work in auto stamping plants or with jet aircraft. Both of these jobs involve noise in the range of 90 to 100 dB, which is potentially damaging in cases of daily exposure. In the case of some jet aircraft, levels can get as high as 160 dB. Earmuffs or earplugs, which are required now for those working close to jets, provide good protection against ear damage.

The performer of hard-rock music may subject himself, as he stands directly in front of his amplifier, to a bombardment of sound as strong as 125 dB. This can make, and indeed has made, the musicians partially deaf. Although Beethoven's deafness was not attributable to overexposure to noise, Ades observes that even Beethoven's "Fifth" can be damaging if played at 125 dB. One of Ades's conclusions is if two people sitting next to each other at a concert must shout in order to converse, the sound has reached a potentially damaging level.

Even though the ear is sensitive, and hearing loss cannot be regained, brief exposure to a loud noise can result simply in "temporary threshold shift"; hearing will be bad immediately after exposure, but will recover in a few days. In cases of "permanent threshold shift," there is no recovery of the hearing loss.

Ades believes that even after his research is completed, about three years from now, people may still fail to grasp the impact noise can have on their ability to hear. Before earmuffs became mandatory for those working around jet aircraft, many workers went deaf — though the muffs, and earplugs, were available — because they simply failed to use them. Perhaps, however, there is still room for hope that a "hearing shortage" need not reach crisis proportions before people recognize the insidious threat of noise. ●

OPEN SEASON ON ENGINEERS

For the thirty-seventh time, engineers at the University of Illinois at Urbana-Champaign join forces for their yearly, open-to-the-public celebration of the virtues and opportunities of the engineering field. On March 29 and 30 the College of Engineering hosts its Engineering Open House. The theme this year, "A Man-made World," stresses the vital role of engineering in improving the quality of life for mankind.

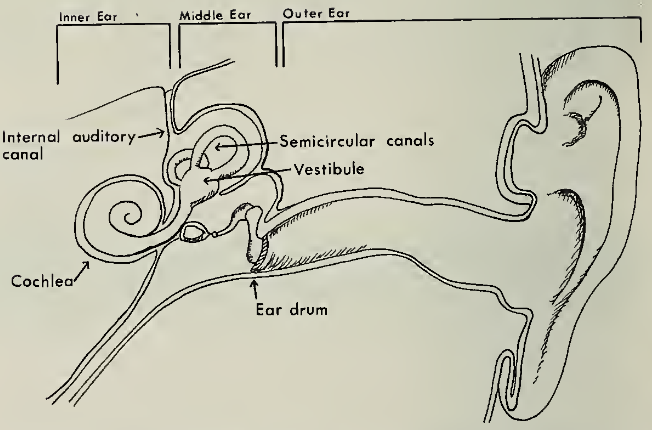
Each year Engineering Open House brings thousands of visitors from Illinois and nearby states to see facilities and activities of the College of Engineering in action. Included will be a number of exhibits displaying scientific principles, engineering applications of those principles, and current research of the college.

Engineering Open House is of particular value to high school students interested in learning about engineering, its opportunities for a career, and the training needed. For them and for other interested citizens, the doors will be wide open. ●

RESEARCH EYES NEEDLE

Research often needles investigators, but at the University of Illinois at Urbana-Champaign one investigator is needling back. He is working on new ways to use and improve fiber-reinforced concrete — concrete which has been strengthened through the use of tiny steel or fiberglass needles.

Almost all concrete structures are reinforced, but the usual method involves the placing of steel bars or welded wire fabric before the concrete is applied. If bars are used they are laid out in the desired pattern, then wired tightly together at each intersection. Welded wire fabric, which comes in various sheet sizes, is more convenient in many cases, because the reinforcement is already laid out and welded together when purchased. In either case, after the reinforcing has been laid and secured, ordinary freshly mixed concrete is placed over it. This method is quite adequate, in fact, preferred, for many structural purposes. In some situations, however, it would be cumbersome or even impossible to use either bars or welded wire fabric; that is where fiber-reinforcing the concrete may provide the answer.



The cochlea, a part of the inner ear which contains "hair cells," important to the process of hearing, is being studied by investigators at the University of Illinois at Urbana-Champaign. They are researching the effects of noise on the hearing ability of the inner ear.

Any one of three types of needles are used in this kind of concrete, and they range from one-half inch to two and a half inches long. The two most common types are made of steel: one from junk steel, such as old car bodies, which has been melted down, and the other from the "leftover steel" of steel companies. A third kind is made of fiberglass.

Fiber-reinforced concrete has the advantage of being able to resist cracking very effectively. Because the fibers are mixed into the concrete itself, they are distributed throughout the mix in many different directions. No matter where a crack begins in the slab, there is most likely a fiber close by to thwart it before it becomes too deep.

Professor Clyde E. Kesler, Departments of Civil Engineering and of Theoretical and Applied Mechanics, and the investigators working with him are studying not only the fibers used for reinforcing, but also the concrete itself. They are developing a quick-hardening concrete "mix" which utilizes two waste products — fly ash, a fine, dusty powder given off by coal-burning factories, and water reducer, a waste product of the paper industry. Not only does this create a valuable use for otherwise useless and troublesome materials, but it allows for less use of portland cement and water, making the mix less expensive.

Kesler sees particular relevance in the application of this project to improved methods in the construction of tunnels. He believes that if fiber-reinforced concrete could be made as workable and easily placed as non-reinforced concrete, and if the mix used could be made to gain strength rapidly, tunnels could be made with slip forms. Slip-forming a tunnel would involve a concrete-placing machine with a length of tunnel form attached to the back of it. As the machine moved through the tunnel cavity distributing concrete, the form would follow after it, creating the tunnel walls from the wet concrete.

By the time the form completely passed over the concrete, the material would have hardened enough to stay in place and support the tunnel. The tunnel could conceivably be ready for use in a few hours.

Other methods involving the quick-setting fiber-reinforced concrete are being applied to tunnel making. These include precast segments for tunnel liners and "sprayed on" liners using quick-drying shotcrete. With these, as with the slip-form method, the problem of building elaborate tunnel forms would be virtually eliminated. Fiber-reinforcing for such tunnels would be especially convenient and effective.

Some of these ideas and research results which had been experimentally applied are being evaluated in the new subway system in Washington, D.C. Successful work with the concrete and its reinforcing needles may prove to be a real shot in the arm for construction techniques. ●

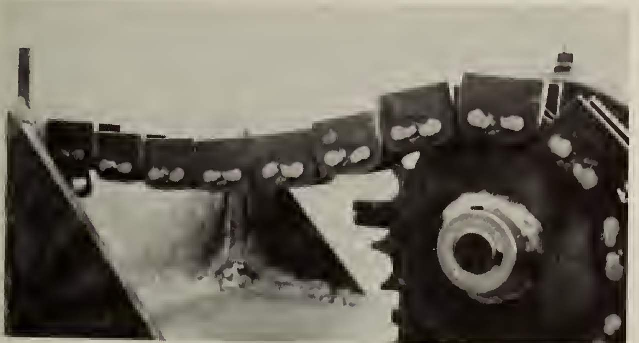
PROVIDING MISSING LINKS

Everybody knows that chains are for pulling — not for pushing. An undergraduate in engineering at the University of Illinois at Urbana-Champaign, however, thought it would be convenient for some industries if there were a chain that could do both — so he developed one.

Roger K. McDaniel had spent one summer working for a firm that used fork-lift trucks. He noticed that when the fork lifted the load into position, a special device was subsequently employed to remove the load from the fork. These devices, designed as attachments to the fork-lifts, used a scissors-jack method of operation — an accordion-like collapsibility — which, while efficient in terms of force used, was complex in design. Consequently the attachments were expensive to buy, and troublesome and costly to maintain.

McDaniel began thinking about how the procedure could be simplified. A system that was strong yet could be made compact was the most desirable, he decided. Certainly linked chains, similar to bicycle chains, were strong, and they could also be stored coiled around a sprocket. The question was how to give them the necessary rigidity. With the help of Professor D. H. Offner, Department of Mechanical and Industrial Engineering, he worked on a solution.

The chain pusher developed by an undergraduate researcher at the University of Illinois at Urbana-Champaign is shown here mounted on a gear reducer, demonstrating the two capabilities of the chain. It bends easily around the sprockets, but is also capable, when extended, of being used for pushing.



The answer McDaniel came up with was surprisingly simple: a modification of the roller-link chain. The usual outside link plates for such a chain are rounded, figure-eight style. McDaniel redesigned the plates to have two rounded corners and two square corners, and slightly higher sides. The chain could then be bent in one direction, for coiling; but when extended, it would be rigid enough for use in pushing. He chose roller link chain with three-quarter-inch "pitch," the distance between the pins in the links.

The concept sounded fine and seemed workable, but the cautious researcher anticipated two problems. One was whether the chain would tend to buckle easily; the other was how much applied force could be withstood by the chain. Through laboratory testing McDaniel found that with the natural bias, or curvature, of the chain, buckling was unlikely under normal conditions of usage. And when the chain was given a compression test, the eighteen-inch length used withstood 525 pounds safely, without noticeable deformation.

McDaniel's creation of a chain that pushes, originally to improve the operations of fork-lift trucks, could start new designer wheels turning in engineering circles for many and varied projects. McDaniel himself has graduated and is employed by an engineering firm — which is probably finding a lot of applications for his pushy ideas. ●

ERG MEANS ENERGY

The University of Illinois at Urbana-Champaign has the ERG to do research on energy usage — in the form of the Energy Research Group. Professors, graduate students, computer experts, and others formed ERG in 1972, and since that time have been investigating various aspects of society from an unusual point of view — as if energy were the currency instead of dollars.

The interdisciplinary group is headed by Professor Bruce M. Hannon, Department of General Engineering and the Center for Advanced Computation. Its studies, sponsored by the National Science Foundation and the Ford Foundation's Energy Policy Project, have concentrated on studying the competing energy-consuming items used in homes or in transportation. They have dealt not only with direct energy consumption requirements, such as the electricity used to operate a stove or the gasoline used to run a car, but also with indirect energy inputs, such as the amount of energy used to assemble the stove, or the amount of energy required to build the highway that the car drives on.

In considering all of the aspects of energy usage for one particular item or activity, the number of variables can sometimes be prohibitive when it comes to drawing conclusions. Under certain conditions — when water for washing is heated with an electric heater, drying is done in an electric dryer, and there is a large number of loads — it could be cheaper, in terms of energy, to do the washing at the laundromat than at home. But there are factors which add to the energy cost of laundromat washing that would not affect home washing, such as the building, maintenance, and heating of the laundromat itself.

The group emphasizes that saving energy does not always mean saving money. And if money is saved by shifting to a lower energy-using good or service, it is often respent in a manner requiring more energy consumption — on a new television set, for example.

The unique philosophy of ERG in not assuming a link between the saving of energy and the saving of money has allowed the members to begin exploring new ways of preserving, and spending, the resources currently available. It is possible that an order of priorities for activities based chiefly on energy consumed will become a reality for many of us in the near future. ●

PEOPLE AND PLACES

Professor **Paul Beck,** UIUC Department of Metallurgy and Mining Engineering, has been named first recipient of the new Hume-Rothery Award from the Metallurgical Society of the AIME (American Institute of Mining, Metallurgical, and Petroleum Engineers). The award is to be given annually to the outstanding researcher in the area of magnetism and electrical properties of alloys.

Moscow was linked to the University of Illinois at Urbana-Champaign with a direct telephone line for ten days in late November — for the purpose of demonstrating PLATO, the computer-based teaching system developed at UIUC. Professor **Donald L. Bitzer,** inventor of the system, also conducted seminars in the Russian capital during the demonstration period. ●

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VOL. 15, NO. 7, MARCH 1974

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inside outlook:

ELECTRICAL PROPERTIES OF BONE
RESEARCH ON PITTING IN ALUMINUM
REDUCING WIND-INDUCED MOTION IN SKYSCRAPERS
REPORT ON ENGINEERING GRADUATES
SUMMARY OF ENGINEERING RESEARCH 1973

THERE WILL BE A SMALL CHARGE

Knowledge about bones is more than skeletal; nevertheless, there appear to be many more areas where discoveries can be made. One finding which could prove valuable in the future treatment of human bone problems is that bones under stress generate electrical signals.

The electrical properties of bone were discovered by a Japanese physicist in 1954. Since that time, though researchers in different fields have examined the subject, relatively few studies have been made. At the University of Illinois at Urbana-Champaign, W. S. Williams, professor of physics, ceramic engineering, and bioengineering, together with physics graduate students Lance Breger and Marvin Johnson, is examining the physical basis for the production of electrical signals in tissues. To do this he is applying what is known about piezoelectricity — "pressure" electricity — to his experiments with bone bending.

In the experiments, long slabs of dry bone about a millimeter thick are used. The bones are usually from a cow's leg, because they are large and easy to work with. Each bone is held firmly at one end in a horizontal position (a bending situation referred to as cantilever) and two copper foil electrodes are attached, one each to the upper- and undersides of the bone. Wires which lead to the voltage-measuring equipment are soldered to the electrodes. The bone is then bent and released, much like a diving board, and the voltage produced is measured.

Many investigations done by others in the past had used uniaxial compression (squeezing) to produce signals. Williams expected his bending technique to produce nearly the same results, following the piezoelectric theory that voltage is proportional to stress. Surprisingly, however, bending the bones resulted in greater voltage than expected; moreover, as the electrodes were moved closer to the supported end of the bone, the voltage increased, sometimes to as high as one volt. These large signals were detected through the use of an automatic null circuit designed by Breger, which showed that for bent dry bones the signal is 100 times greater than originally believed.

Piezoelectric theory also couldn't explain the fact that when the experiment was tried again with the supported and free ends of the bone reversed, the sign of the voltage remained the same, rather than reversing as expected. Investigation of these puzzling turns of events led to a successful modification of the basic idea: voltage was proportional to stress plus the gradient of stress (changing degrees of pressure).

Bones undergo changes much more extensively and often than we realize, and these electrical properties and characteristics may play a significant role in such changes. Bones remodel under stress, for example, so that when people gain or lose weight their bones become thicker or thinner proportionately. This may be due to changes in the electrical signal that the bone receives from the change of stress in walking. This concept led to speculation about whether the introduction of electrical stimuli from an outside source could result in increased bone development. Williams, Professor G. H. Kenner from the College of Veterinary Medicine, and undergraduate biology major Edward Gabrielson applied electrodes to rabbits in whose leg bones osteoporosis (brittleness resulting from inactivity) had set in. They found that an early form of bone tissue did begin to grow near the electrodes. As fundamental understanding increases and techniques are perfected, an effective treatment could result for the osteoporosis problem that occurs among elderly individuals.

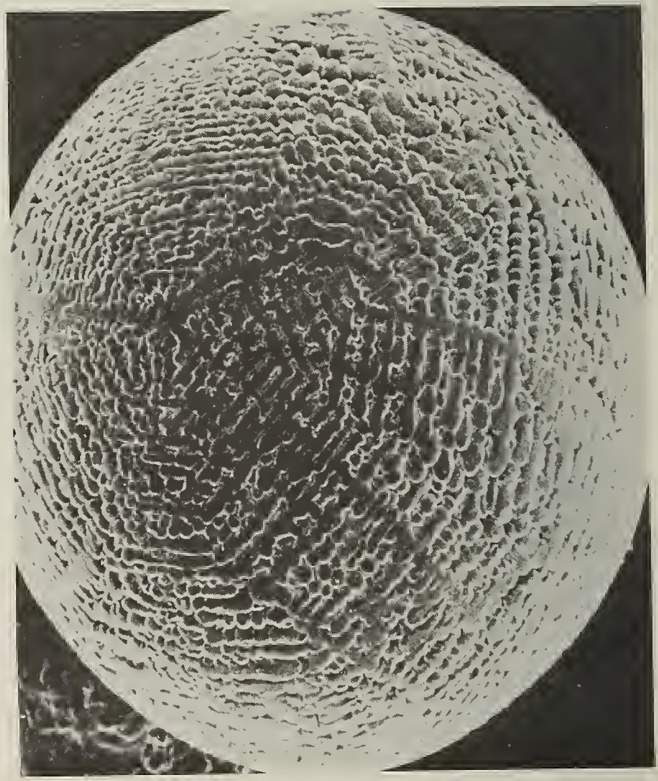
Application of electricity to bones has already been used to accelerate fracture healing, and it is possible that in the future electrical stimulation could be used for regeneration of bone and other tissue. Electrical signals also could prove constructive in treatment of cancerous cells and tumors. Williams acknowledges that many of these results are a long way off; but it is conceivable that for future research in areas relating to men and animals, bones could provide a supportive framework. ●

PITS AND PANS

How many times a week do you see films? A great deal more often than you think if you work with things made of aluminum. Aluminum is used for innumerable products, from construction materials to pots and pans, not only because it is lightweight but also because it produces its own protective film that keeps it from corroding. However, this self-made film has its own built-in problem: the sometimes-random, sometimes-systematic development of "pits," or small cavities, on its surface. How and why these pits form is not fully understood. A researcher at the University of Illinois at Urbana-Champaign is currently doing studies on pits, film, and aluminum itself to find out how to predict and eventually inhibit pit formation.

Aluminum is an unusual metal. There is no justification in its chemical nature for the fact that it doesn't disintegrate, except that it produces the essentially insoluble film. The film is thickened when aluminum is boiled in water. It is this film buildup that causes the discoloration of pans used in cooking. Nevertheless, it is not a good idea to stop scouring your pots; this film usually has defects, causing pits for which scrubbing could be helpful. Professor M. Metzger, Department of Metallurgy and Mining Engineering, and the two graduate students working with him believe that pits always start as a result of minute defects in the film which allow the aluminum to begin dissolving around them. Aluminum is particularly susceptible to this because of its electrochemistry. Chlorides are particular villains in the pitting process. Their presence can help to start it or to speed it along. The frequent use of salt water can cause a case of virtual acne on the surface of an aluminum pot.

It has been a source of confusion to researchers in the past that pits, once started, could continue to grow at all. It would seem that the aluminum would immediately produce its protective film to fill up the hole and stop the pit from growing. Metzger discovered that pits form in different ways and under varied conditions, and the right combination of formation type and environment would allow the pit to grow to the point of disintegrating the aluminum. In that pan of salt water, for example, perhaps there is a defect in the film which causes a hole and exposes the aluminum underneath. The positive aluminum ions attract the negative chloride ions, which quickly and constantly flood in, widening the pit beneath the film on all sides of the hole. The film surrounding the hole is now in fact protecting the pit and, with the help of the chloride ions, promoting its growth. If the film covering the pit is scrubbed away, the stability of this growth environment is upset, and the aluminum is able quickly to reform its film and choke off further corrosion. Scouring then, rather than making the film less effective, actually allows defects to mend themselves.



When a jet of molten iron is sprayed into a stream of cold water, thousands of tiny iron droplets like this one are formed. In this electron micrograph the surface pattern caused by the rapid freezing of the droplet is clearly visible. The experiments with iron are part of a project in metallurgy being conducted by Professor Charles A. Wert at the University of Illinois at Urbana-Champaign.

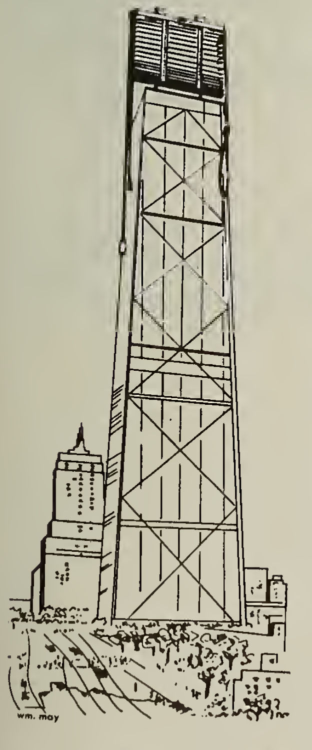
In addition to the pitting which occurs randomly, there is a type which is more systematic — intergranular pitting. In this situation the pits form along the grain boundaries of the metal beneath the film, and can cause the metal eventually to disintegrate into a powder. Whether pitting will be random or intergranular depends upon the nature of the film and the differences in composition associated with the grain boundaries of the alloy. Metzger is examining the geometry of film structures as one method of discovering how pitting and intergranular corrosion occur. By learning more about the mechanism of the pitting process and the behavior of films under certain conditions, he hopes to provide a more rational basis for the design of aluminum alloys which can be formulated to obtain high strength but will not be susceptible to the various forms of localized corrosion. Aluminum can then be used more versatilely and will pit less frequently in surroundings for which it was specially designed.

In some cases, such as in certain electrolytic condensers, the pitting phenomenon can be put to good use in increasing the surface area and thus increasing the efficiency of electrolytic capacitators. But for most of us, who simply don't want our aluminum utensils to wear out, Metzger's research will help to provide a solution to the hole problem. ●

ARREST THAT BUILDING!

Modern skyscrapers are in a highly unique position: they sway in the wind. Though the motion is not dangerous and is often virtually imperceptible, it does present some peculiar, irksome problems. For apartment dwellers, these mean hanging pictures that gradually tilt and shift on the wall, or periodic moments of seasickness. For the restaurant on the ninety-fifth floor of the John Hancock Center in Chicago, they mean wines and champagnes must be kept in the basement so they won't cloud up due to agitation.

A mechanical engineer at the University of Illinois at Urbana-Champaign has developed a simple, practical way to reduce building motion by 90 percent using the same wind force that started the building moving in the first place. All the building needs, says Professor R. E. Klein, is a Venetian blind sitting on top of it.



In this whimsical artist's rendering, the "Venetian blind" concept for reducing wind-induced motion in skyscrapers is shown applied to the John Hancock Center in Chicago.

Klein came to his somewhat unorthodox conclusion after a good deal of investigation into the history of skyscraper construction. It used to be that the buildings could resist wind-induced motion simply through weight and horizontal stiffness. The Empire State Building in New York, built in 1931, has a solid granite exterior, interior load-bearing walls of concrete, and twenty-foot spacing between columns. This type of structure was quite feasible at the time, because the materials were not prohibitively expensive and the relatively small room size allowed by the twenty-foot column spacing was adequate for office and other needs. As time went on, other factors made the methods used for the Empire State Building impractical for future skyscrapers. The combination of rising costs for granite and concrete, a need for taller buildings with proportionately equivalent strength, and a need for greater roominess and versatility in office and apartment space dictated a change in construction techniques. Modern tall structures often have glass shell exteriors, non-load-bearing movable interior walls, and forty-foot column spacing. Although they are strong, they are much lighter, and subject to buffeting by the wind.

There are several ways in which wind affects skyscrapers, depending many times upon how the wind itself is directed and controlled by the position of other structures in the city. Gusts cause intermittent blasting of skyscrapers with strong winds; the skyscraper could be caught in a trailing wake from a nearby (upwind) building. Or the skyscraper could be victimized by vortex shedding, a phenomenon whereby swirling eddies, or vortices, of wind are created on the downstream side of the building. All of these types of wind attack mean that the building does not simply stand still and bend in one or another given direction, but sways and rocks in any number of motion combinations.

Some methods of inhibiting this motion have already been proposed. One involves the placing of a huge tank of water on the top of the skyscraper to slosh back and forth and absorb some of the building's movement. This, however, would add a lot of weight to the building and be very awkward to implement. Another plan is to add movable weights and dashpots (similar to automobile shock absorbers) to the top of the building to minimize swaying. This too would add weight.

Klein's idea is that a Venetian blind with an area just 2 percent that of the building will reduce by 90 percent the building's oscillation. The device, which could be made of aluminum, fiberglass, or some other strong, light material, would be mounted on top of the building and be able to rotate to face the wind. Whether the blind were in an open or closed position would be determined by the relationship of the wind to the motion of the skyscraper.

If the wind struck the building from the south, for example, the building would begin to bend toward the north and the blind would be open, allowing the wind to pass through. But as the building began to sway back again, the blind would close, increasing the area of the building in opposition to the wind. Thus the very force which began the swaying would be used to dissipate energy in the building structure caused by the building's movement.

The operation of the blind could be readily accomplished. A gyroscope or laser could detect the motion of the building and hydraulic or electric motors could control the rotation, opening, and closing of the device.

Klein has been working with his colleagues for two years on his concept. He believes that his motion-inhibiting method can really work — which shows that even a practical engineer can have a little blind faith. ●

FOR BETTER OR WORTH

How valuable is an engineering degree? Reports on the progress of the UIUC engineering graduates of 1963 and 1968, recently issued by the Placement Office of the College of Engineering, indicate that careers start out good and keep getting better.

Graduates in 1963 started their careers at an average monthly salary of $596. Five years later, the average was up 65 percent to $983, and currently the average 1963 UIUC engineering graduate earns $1,590 monthly.

Engineers from the class of 1968 have fared equally well, averaging $1,291 each month in 1973, a 66 percent increase over their average starting salary of $776 five years ago.

Last June, UIUC engineering graduates started at $933 a month — 55 percent more than the average beginning salary ten years ago and 20 percent more than five years ago.

The top monthly salary in the class of 1963 is $4,300 a month, earned by a civil engineer; and an electrical engineer from the class of 1968 tops that group, earning $6,000 a month. Both have their own businesses — and they round out the list of satisfying careers of engineering graduates from the University of Illinois at Urbana-Champaign. ●

SUMMARY AGAIN THIS WINTER

How the College of Engineering of the University of Illinois at Urbana-Champaign spent nearly fifteen million dollars last year for work toward the betterment of mankind is succinctly described in *The Summary of Engineering Research 1973,* recently published by the College's Engineering Publications Office.

The 199-page book reports on some 700 research projects involving 500 UIUC faculty and professional staff members and 1,200 graduate students earning master's and doctorate degrees. It is the sixteenth in an annual series of reports on the UIUC engineering research program. The *Summary* reports on the research of all engineering departments, the Department of Physics, the Nuclear Engineering Program, and the Department of Computer Science.

The publication is free to UIUC students, faculty, and staff, and available for $1.00 to others, from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

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inside outlook:

REDUCING NOISE IN JET ENGINES
ELECTROMAGNETIC RAILROAD SYSTEM
DEPARTMENT HEAD RETURNS TO THE LABORATORY
NEW WATER POLLUTION CONTROL STANDARDS
UIUC ENGINEERS ELECTED TO ACADEMY
NEW SHAPE FOR AIRFOILS

BYPASSING NOISE

Air is rather unobtrusive when it is just sitting around, but at high speeds and under turbulent conditions it can begin to get loud and obnoxious. One situation in which this problem arises is in and around an operating jet airplane engine. An engineer at the University of Illinois at Urbana-Champaign is studying one aspect of the problem: how to make the expulsion of air and gasses from the jet engine less noisy.

In order to operate, a simple jet engine takes in air and compresses it. Fuel is mixed with the air and burned; hot gasses are exhausted through the turbine and expelled into the surrounding atmosphere. This jet of gasses produces a great deal of noise because of the turbulence that is generated. The problem is compounded by the interaction of that turbulence with the surrounding, slower-moving air. A bypass engine operates in much the same way as a simple engine, except that some of the air taken in is simply blown out again, bypassing the turbine, and is never mixed with fuel or heated by combustion. Professor B. G. Jones, UIUC Nuclear Engineering Program and Department of Mechanical and Industrial Engineering, is developing a bypass jet engine in which the main air flow from the turbine can be surrounded by a cold, secondary flow, which he believes will cut down on the amount of turbulence and the resultant noise.

For his research, Jones created a unique pressure transducer, which measures fluctuating pressure independent of the velocity of the airflow. This makes the instrument ideal as a means of describing the sound source because it can be used to measure only the fluctuating pressure field in the turbulent exhaust from the jet engine. This is much simpler than measuring the velocity field in describing the sound source, which conventional instruments do, because pressure has magnitude only, while velocity includes both magnitude and direction. This reduces the number of measurements necessary. The transducer can be conveniently used in heated jet environments because it is rugged and heat resistant.

With the pressure transducer, and through mathematical modeling, Jones has done tests and experiments on small jets. His goal is to be able to predict the intensity, location, and frequency of noise levels, through development of an appropriate model, and ultimately to determine how to reduce those levels as much as possible through the modification of flow conditions and jet dimensions for the engines. When the project is completed, those who work around aircraft may have some deafening cheers of their own to deliver. ●

MAGNETIC TRAINS NEED CONDUCTORS

It may be refreshing to know that even among serious engineers, transportation is being treated with levity. UIUC investigators are currently contributing to the related work of the U.S., Japan, Germany, Great Britain, and Canada in creating a railroad type of transportation system based on electromagnetic levitation.

The idea was introduced to the general public at the world's fair in 1972, when a working model of one of the two types of systems was displayed for visitors. Since December of that year, Professors S. W. Lee and R. Mittra, UIUC Department of Electrical Engineering, and R. C. Menendez, graduate researcher, have been doing analyses of the theoretical electromagnetic aspects of the project.

Behind the search for a new transportation system was the realization that the speed and comfort capacities of current ground transportation, particularly trains, were inadequate to meet growing needs. To be a useful form of public transportation, they should be faster and, at the same time, provide a less bumpy ride. The wheel as a means of guidance and propulsion, however, had reached its practical limits; and investigation revealed the use of magnetic forces as being the most reasonable alternative.

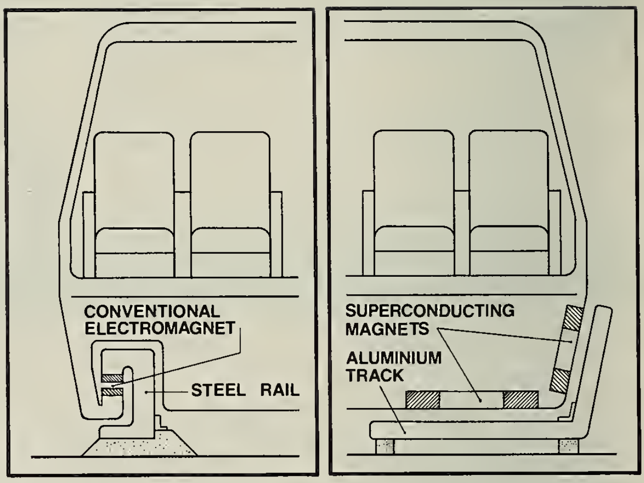
There are two types of electromagnetic levitation systems being considered: attractive levitation and repulsive levitation. In the attractive system, the track is made of iron and grooved on the outside edges. Electromagnets extend from the bottom of the train cars over the edge of the track and into the grooves. A control system built into the train regulates the attractive force between the electromagnet and the iron track so that the train is kept lifted about one inch from the ground.

In the repulsive system, aluminum or a similar nonmagnetic conductor is used to make the track; superconducting magnets are built into the bottom of the train. As the train picks up speed, eddy currents generated by the interaction of the magnets with the track lift the train about one foot from the ground.

Lee, Mittra, and Menendez have been concentrating their research on the theoretical testing and improving of the new trains for various uses. Each of the two systems is appropriate to different types of situations. For fast travel over short distances with frequent stopping — intracity, for example, or within some similar limited area — the attractive levitation system is more desirable. It does not require a buildup of speed to lift it off the ground; in fact, its maximum lift is at zero velocity. Also, because the gap maintained through control of the electromagnetic force is only one inch, it is a less stable system for extended periods of high-speed travel. The repulsive system, on the other hand, gains lift along with speed; the faster the better. Traveling at 300 miles per hour over long distances would be not only possible but safe.

In addition to being able to travel more rapidly, the electromagnetic systems have another advantage over wheels. Drag forces, which build up between the wheels of the conventional train and its track, increase as the speed of the train increases. In the new systems, although these forces exist, they reach a peak at a relatively low speed, and then decrease as the speed increases. One of the concerns of the three UIUC engineers has been obtaining in both systems as much lift as possible with as little drag as possible.

A major expense, should the new systems be put into operation, will be the track, as it is with any railroad system. In this area, these particular attractive and repulsive systems are more practical than others that have been proposed, because the track used is not required to be active (magnetized). If active track were required, the system would be prohibitively expensive.



Shown here are cross section diagrams of two new proposed railway systems using electromagnetic suspension. Research by engineers at the University of Illinois at Urbana-Champaign is contributing to the further development of these two systems, which are specially designed for high-speed transportation.

Even after extensive research has been completed, the UIUC investigators believe that popular acceptance and support of the new systems will be necessary before they can be definitely adopted. But there is no doubt that if the electromagnetic railroads begin operating on a large scale, the public will be well trained. ●

DEPARTMENT HEAD RETURNS TO THE LABORATORY

Professor Helmut H. Korst, head of the UIUC Department of Mechanical and Industrial Engineering for more than a decade, has relinquished his administrative post and will return to a full-time academic role. Professor Korst, who is internationally known for his work in fluid mechanics, gas dynamics, and propulsion, is a fellow of both the American Society of Mechanical Engineers and the American Institute of Aeronautics and Astronautics. He will devote more time to his current research interests which include blast fields and internal ballistics of rocket engines.

Professor Korst was educated at the Technical University of Vienna and has been associated with UIUC since 1948. He was named a full professor in 1951 and appointed department head in 1962. Professor J. W. Bayne is serving as acting department head until a successor is appointed. ●

EXCEPTIONAL EXCEPTION

The best way to control water pollution has always been debatable, but one method, in some cases, has been underestimated: that of letting nature take its course. One UIUC civil engineer has proved that, in Illinois at least, extensive treatment of wastewater is not necessary.

Natural processes themselves contribute greatly to water purification.

Professor John T. Pfeffer began working in 1971 with the Illinois Institute of Environmental Quality to set up treatment regulations for Illinois rivers and streams. Guidelines that had been used for years to establish treatment requirements were being examined for possible adoption as full-fledged regulations for plants discharging wastes into the water.

There were two major considerations in setting the standards. One was biochemical oxygen demand (BOD), which is a measure of the oxygen that is required to stabilize the waste material in the water and protect plant and animal life. The other is the amount of suspended solids in the water as a result of the waste discharge. In rivers or streams in which the flow of water was in a ratio of 1 to 1 with the flow of sewage, the guidelines specified a "4-5" standard: no more than 4 milligrams per liter BOD, and no more than 5 milligrams per liter of suspended solids.

The treatment of water to keep it up to these standards had been very expensive. Pfeffer thought the standards unreasonable for Illinois bodies of water, because they are shallow and wide and can absorb a lot of oxygen, or reaereate, due to the wide surface area in contact with the air. Based upon this natural reaereation, Pfeffer determined that a "10-12" standard would be adequate to maintain high water quality, and would be much cheaper to attain than a "4-5" standard. In addition, Pfeffer claimed, artificial aeration could be preferable to treatment in cases where water needed extra help in remaining safe.

He was able to prove his case, and now the Illinois Pollution Control Board has enacted the "Pfeffer Exception," as his idea came to be called. Sewage plants that can qualify for it are saving as much as 20 percent in capital costs. The technique has been put into practice in Germany and is being considered in Chicago. Treatment costs in Germany have dropped to one-third or less of their former rate. Estimated savings for Chicago are ninety-eight million dollars.

The Pfeffer Exception shows signs of being adopted as practical in areas all over the country — which will help make for better water everywhere, no matter what's dropped in the drink. ●

KUDOS

One of the highest distinctions that can be conferred on an American engineer is election to membership in the National Academy of Engineering. Three professors at the University of Illinois at Urbana-Champaign have been recently honored with that distinction: Professors Donald L. Bitzer, James W. Westwater, and Thomas J. Hanratty.

Bitzer, an electrical engineer, was named for "leadership in the utilization and development of technology for improving the effectiveness of education." He is the inventor of the PLATO (Programmed Logic for Automatic Teaching Operations) computer-based education system and coinventor of the plasma display panel.

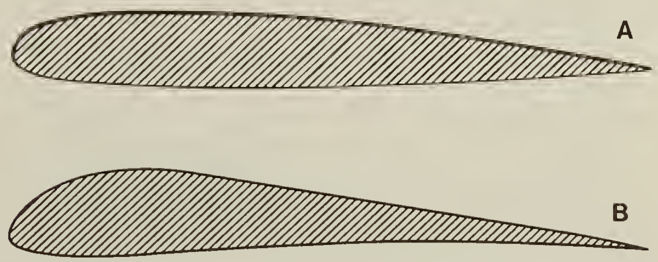
Westwater, head of the UIUC Department of Chemical Engineering, was honored for "contributions to boiling heat transfer by high-speed photography at great magnification." He has taken motion pictures at 6,000 frames per second through a microscope, with magnification on the film of sixty-six times, as part of his procedures for studying boiling.

Hanratty, a chemical engineer, was elected to membership for "contributions in the analysis and design of turbulent, gas-liquid and solid-liquid flow systems." His work has been important in catalytic reactors, film-cooled rocket motors, cooling of nuclear reactors, and transport of liquids in pipelines.

Thirteen other members of the UIUC engineering faculty are also members of the academy. Now sixteen of the 507 members can make further influential contributions while training other up-and-coming engineers to follow in their footsteps at the University of Illinois at Urbana-Champaign. ●

FOILED AGAIN

Aeronautical engineers who decide to wing it may find that their research gives everyone a lift. That happens to be the situation with one investigator at the University of Illinois at Urbana-Champaign: he has been developing new shapes for airfoils — wings, propellers, and other stabilizing parts of an airplane — in order to increase the amount of lift they can provide.



Below is a cross section (front is to the left) of a new design for airplane wings, propellers, and other airfoils, which was developed at the University of Illinois at Urbana-Champaign. Above is a cross section of a typical, currently-used airfoil design. The chief difference in the new model, designed for greater lift capabilities, is its shape, an important factor in directing the air flow past the wing when in flight.

When a pilot wants his plane to go up, he tilts the whole plane, raising the front end. The speed of the plane and its wing position combine to give the plane lift. Up to a point, the more the plane is tilted, the greater the lift. However, at a certain angle of attack on the wing, a stall occurs. The air flow past the wing separates and turbulence is created above the wing, causing the lift to decrease. One method of increasing lift while avoiding stalls is to increase the speed of the aircraft, but this is not always safe, especially in smaller aircraft. The ideal answer is a wing designed for higher lift at lower speeds.

Professor A. I. Ormsbee, UIUC Department of Aeronautical and Astronautical Engineering, has been working on optimum shapes for wings that do just that. They increase lift by increasing the angle of attack at which the stall occurs. He developed several mathematical models, tested them in a computer, and came up with a theoretically optimum shape. Recently he built an aluminum model of it and successfully tested it in a wind tunnel. Ormsbee believes that the new airfoil will be no more difficult or expensive to make than the usual one.

Applications for the new airfoil shape include not only entire airplane wings but also wing "flaps," the small, moveable surfaces at the rear of the wings that regulate drag. Ormsbee is also investigating the use of his high-lift-inducing airfoil design in propellers. The increased lift will make them much less noisy and their decreased diameter, as compared with the usual propeller design, will also have a quieting effect.

After five years of work on this project, and many years before that of related work, Ormsbee and the engineers he works with are in a position to say that the future of airfoils and the planes they are connected to is definitely looking up. ●

PEOPLE AND PLACES

The UIUC student branch of the Institute of Electrical and Electronics Engineers has won a Bendix grant from the national IEEE for its proposal to redesign the control system for electric wheelchairs. A student member of the IEEE at the University of Illinois at Urbana-Champaign was also elected to the national Student Policy and Planning Committee as the representative from the midwestern region.

Two professors from the Department of Physics at the University of Illinois at Urbana-Champaign have been elected to positions in the American Physical Society. **R. O. Simmons**, head of the department, became the vice-chairman-elect of the Division of Solid State Physics of the APS. The position leads to vice-chairman and chairman in succeeding years. **David Lazarus** will serve a four-year term on the APS governing council. Also elected as a member-at-large was UIUC alumnus **Howard B. Etzel.**

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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COLLEGE OF ENGINEERING
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inside outlook:

POPULATION AND ECONOMICS SEMINARS
STUDY ON TRANSPORTATION FOR THE ELDERLY
SUMMER WORKSHOP FOR HIGH SCHOOL TEACHERS
UIUC TESTING ELECTRONIC BLACKBOARDS

POPULATION UPS AND DOWNS

Many engineers have been concerned about the future availability of natural resources and technology's role in preserving them. But one group of UIUC engineers and social scientists in the Coordinated Science Laboratory has addressed itself to the problem of how many people will be around to use them up. The group, headed by Professor Paul Handler of the Departments of Physics and Electrical Engineering, has developed a set of seminars in population dynamics and economic development. They are open to students, planners, and government officials all over the world as research and educational aids.

Work on the seminars was begun a year ago, and by this July 1,500 people from various countries will have participated. The United States Agency for International Development (AID) is funding the five-year project.

Handler's team, known as the Population Dynamics Group, created computer programs for use with PLATO, the computer-based educational system invented at UIUC. The programs enable seminar participants to study current situations and future projections in various areas such as fertility and mortality rates, population's effects on public expenditures, variations in the labor force, and demand for natural resources. Most of the developed and less developed countries can be studied. The program has been designed so it does not require any special mathematical or computer skill.

Currently five centers have been set up where the programs are held. At each center the seminars, conducted by Handler or any of the four other trained instructors, consist of lectures, discussions, and explorations of whatever aspects of population problems are of interest to the group. PLATO can interact with the participants according to their needs by presenting questions, posing alternate possibilities, or providing answers in words, figures, or graphs. The programs are designed to give insight into population's relation to various social problems. Apparently they have met with success; AID has even decided to include participation in one of the seminars as part of its orientation program for new employees.

Handler plans to establish two more centers in the United States, and eventually at several overseas points as well. The foreign centers will use a minisystem currently in the developmental stages. If the program is successful in generating awareness and practical ideas, some uncommon solutions to common problems may be available to us in the near future. ●

MATURING MASS TRANSIT

Mass transportation may not always be the most convenient way to get there from here, but for some people, especially the elderly, it may be the only way. In large cities with several modes of public transportation and widely varied schedules and pickup points, it is usually possible to accommodate their needs. But the majority of elderly people in medium-sized cities — those with a 50,000 to 250,000 population — often have only a bus system to depend upon, a system which is used infrequently and has only limited route coverage. Two civil engineers at the University of Illinois at Urbana-Champaign decided that these twin cities, with a combined population of 125,000 and a sizeable percentage of elderly citizens, offered an excellent opportunity to study the transportation needs and problems of these citizens, and to determine possible changes.

Defining "elderly" as "sixty-five years of age or older," Professor Moreland Herrin and former graduate researcher Vaun Clayton Weaver drew a random sample of elderly citizens from a list of names. Then they arranged for volunteer elderly citizens themselves to conduct the telephone survey. The questions centered around attitudes toward various aspects of mass transportation, so that the results could be applicable to other cities.

The researchers found that it was not cost but convenience which determined the mode of transportation used chiefly by the elderly. The convenience factor applied not only to destinations but to points of origin — how far they had to walk to catch the bus. This was particularly important because of the incidence of physical problems which limited mobility. As many as 53 percent of those surveyed were "captive riders"; they had to use public transportation because no auto was available to them or they had no driver's license. This meant that especially for those who were retired — as more than 90 percent of the respondents were — the bus schedule could be playing a significant role in determining how they spend the rest of their lives.

Herrin and Weaver used their results to arrive at several possible improvements in public transportation to better serve the needs of the elderly. One idea was to develop a reduced-fare taxi program, so that those with physical problems and no available auto could better afford the door-to-door service a taxi provides. Another was to institute a specially designed vehicle as a complement to the mass transit system with features such as nonslip, low-rise steps, extendable handrails, foam-padded bucket seats with headrests, and other conveniences. This could be used to offer demand-responsive, low-cost, door-to-door service to the elderly in the community. The engineers also suggested that groups of elderly people currently operating their own systems to accommodate their needs receive continued encouragement from local citizens. The move would help to bring to the forefront greater public interest in related problems. After all, public support of improved mass transportation is one bandwagon most people would be glad to jump on — if it stops in their neighborhood. ●

UNTRACEABLE WATER

Proceedings of the recent Sixteenth Water Quality Conference, which was conducted jointly by the American Water Works Association, the Illinois Environmental Protection Agency, and the UIUC Department of Civil Engineering, are now available. The booklet contains twelve articles related to the theme, "Trace Metals in Water Supplies: Occurrence, Significance, and Control." The articles deal with such problem areas as the relationship between trace metals in water and chronic diseases, and methods of detecting and removing trace metals in public water supplies. Copies of the publication are available from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801, at a cost of $9.00 per copy. ●

POWER FOR HIGH SCHOOL TEACHERS

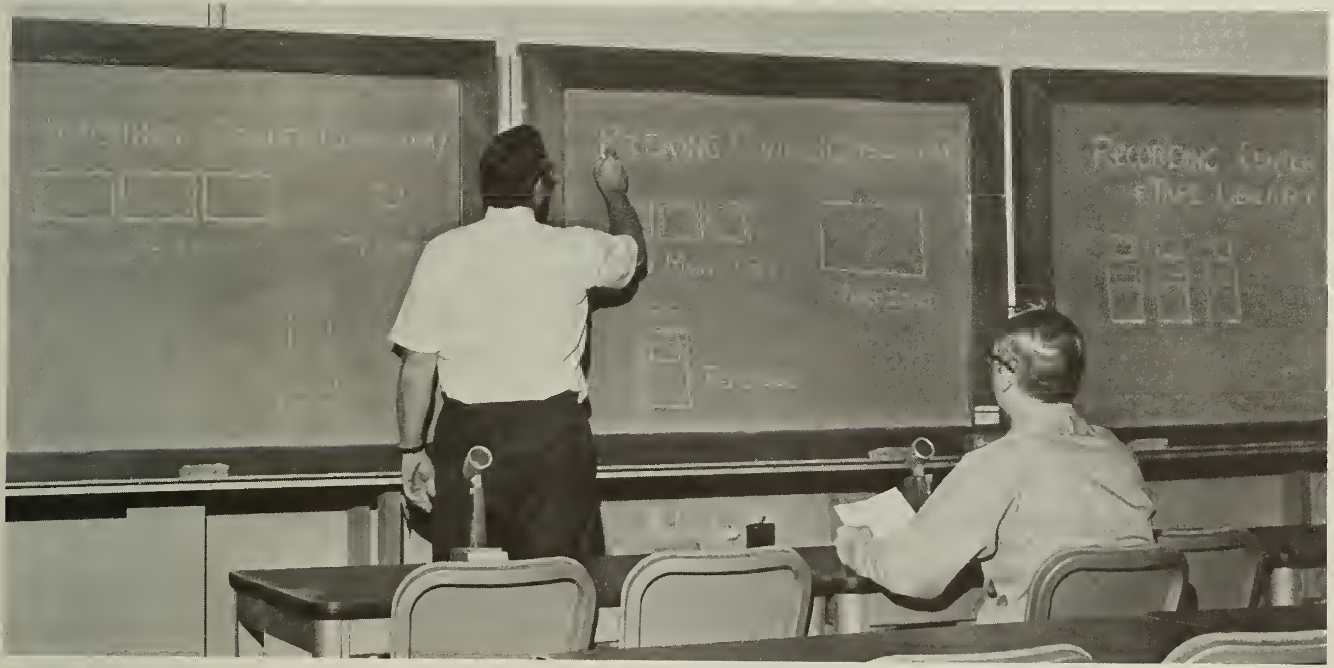
A summer workshop, "Electric Power Generation from Nuclear Energy," is being conducted August 5–9, 1974, by the Nuclear Engineering Program of the UIUC College of Engineering for secondary school teachers. Sponsored by the Division of Biomedical and Environmental Research of the U.S. Atomic Energy Commission, the workshop is designed to survey the economic, environmental, and technical aspects of nuclear energy. Participants will have the opportunity to become acquainted with the principles of nuclear energy, and to understand the comparative risks and benefits of fossil and nuclear fuels. High school teachers interested in participating should write immediately for information to Ed Kalb, Conferences and Institutes, 116 Illini Hall, Champaign, Illinois 61820. ●

BOARD OF EDUCATION

It was an important moment for the University of Illinois at Urbana-Champaign when Jimmy W. Seyler opened his telephone bill. There was really nothing extraordinary about the bill itself; but an article in the accompanying newsletter caught his eye. Bell Laboratories had developed a new system for classroom interaction over long distances. Seyler, who is UIUC's academic coordinator of extension in engineering education, called an Illinois Bell representative to inquire about the possibility of the University testing the equipment for them. A series of telephone calls and conferences began between Seyler, Illinois Bell, and Bell Laboratories in New Jersey. The results are that, since January, the UIUC College of Engineering has had at its disposal an unusual audio-visual system, the only one of its kind in the United States: the Remote Blackboard.

It looks like an ordinary blackboard, right down to its color — green — except for a telltale metal box in the corner, housing the controls. The pressure-sensitive chalkboard is specially designed to transmit whatever is written on it over an ordinary voice-grade telephone communication network. Microphones designed to transmit over the same network are used by the instructor as he teaches — allowing both lecture and written explanations to be conveniently conveyed to any receiving center.

As a result of this novel system, the receiving centers can be anywhere that is available by telephone. What the instructor has written on the blackboard appears on



Remote Blackboards, long-distance teaching aids created by Bell Laboratories, are currently being tested at the College of Engineering of the University of Illinois at Urbana-Champaign. Shown here is a teaching center set up in a classroom at UIUC, from which graduate engineering courses are transmitted "live" to three receiving centers in Illinois. The microphones on the tables allow questions and comments of students in the room also to be transmitted.

a television set, and his words are broadcast over the speaker of a standard conference telephone set. If the teaching center is an actual classroom with other students present, microphones can be made available on their desks so that their questions and comments can be heard at the receiving centers.

UIUC has been using the new system to teach graduate engineering courses. Receiving centers have been set up in Rockford, Freeport, and Rock Island, Illinois. Professors travel to the cities to meet personally with their students for the first one or two sessions of the class. After that, teaching through the use of the Remote Blackboard isn't any more impersonal for the students than a telephone conversation.

The particular beauty of the system is the opportunity it allows for immediate, two-way communication. Receiving centers can have, in addition to their television sets and speakers, a blackboard and a microphone for asking and answering questions or illustrating and solving problems. A television and speaker at the teaching center completes this aspect of the system very simply.

For students who have to miss a session, for professors with an occasional time conflict, or for purposes of review, special equipment enables the entire lesson, video and audio, to be recorded on an ordinary tape cassette. The device, usually housed in a cabinet beneath the television set, can then play back the class session as originally taught, including visuals, questions, and answers. A library of recorded class sessions can be kept at the teaching and receiving centers for the students' use.

A number of UIUC engineering professors have used the system, and all are enthusiastic. Seyler believes that in the future, when the system becomes generally available, residency requirements at many universities can be satisfied by students simply attending class sessions at a nearby receiving center — the same classes being taught on campus.

In the six months of testing, UIUC has already been able to make several suggestions for improving the practicality of the boards for teaching. One idea has been to use several boards in the teaching center instead of just one, with a corresponding number of television sets in the receiving centers. Testing will continue for about one more year; then the boards are expected to be available for renting by the general public. For many of the hitherto uninitiated, Bell Laboratories' new system and UIUC's extramural teaching expertise may turn off-campus education into a remotely interesting experience. ●

A FIRST IN THREE SECONDS

The University of Illinois at Urbana-Champaign led the nation in the total number of chemistry and chemical engineering degrees conferred last year. To do it, UIUC took second place in each of the three categories: second to Wisconsin in the number of bachelor's degrees;

second to Purdue in master's; and second to MIT in doctorates. UIUC students and professors must be trying harder — and it paid off. ●

PEOPLE AND PLACES

Keramos, national professional ceramic engineering fraternity, has conferred its 1974 Greaves-Walker Roll of Honor award upon Professor Emeritus **Dwight G. Bennett,** UIUC Department of Ceramic Engineering. Bennett was national president from 1938 through 1940, and has held numerous other offices in the organization.

The U.S. Secretary of Transportation has named Professor **Marshall R. Thompson,** UIUC Department of Civil Engineering, a National Defense Executive Reservist. This designation recognizes executive ability and performance in the highway field on the national level, and willingness for public service.

The Illinois section of the American Water Works Association has selected Professor **Richard S. Englebrecht** to receive the "Man of the Year" award for 1974. Englebrecht, a civil engineer, was cited for his outstanding professional contributions and service to the field of water supply.

Professor **Ven Te Chow,** UIUC Department of Civil Engineering, has been presented a Western Electric Fund Award by the American Society for Engineering Education. The award recognizes excellence in engineering instruction and outstanding contributions to the engineering profession.

Professor **James W. Bayne,** acting head of the UIUC Department of Mechanical and Industrial Engineering, has been reelected to a second term as president of the Association of College Honor Societies. The association includes forty-seven societies of which seven were founded at the University of Illinois at Urbana-Champaign.

Professor **Edward C. Jordan,** head of the UIUC Department of Electrical Engineering, has been elected an eminent member of Eta Kappa Nu, national electrical engineering honor society. Conferred annually, it is the highest award given by the society.

Professor **Chester P. Siess,** head of the UIUC Department of Civil Engineering, has been made president of the American Concrete Institute. He has been vice-president for the past two years, and has also served as director on various committees. ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL. 16, NO. 1, AUGUST 1974

inside outlook:

- RESEARCH ON MARTENSITIC METALS
- BENDIX AWARD RECIPIENT
- COMBUSTION MODELS
- DENTAL ENAMEL MICROSTRUCTURE
- UIUC SWE AWARDS

AUGUST ENDEAVOR

This is the second year that wheels have begun turning earlier at the University of Illinois at Urbana-Champaign. The academic year now begins in August and concludes in May. Not to be outdone by these practical adaptations in academia, *Engineering Outlook* is also moving up its ten-month year to correspond with them. Welcome then to the sixteenth year of *Outlook,* which begins its reports, as will all future volumes, in an August issue, and will end them in May. ●

THE NiTi GRITTY

If you get bent out of shape, can you snap right back to normal when the heat's on? Titanium nickel can — it has what metallurgists call a shape memory. UIUC Professor C. M. Wayman, Department of Metallurgy and Mining Engineering, has been examining the shape memory phenomenon in alloys and finding new ways to put that property to practical application.

NiTi (titanium nickel's scientific designation) is just one of the large number of alloys discovered to have a memory. Even brass exhibits this property under certain conditions. The structure of these alloys and the way in which their atoms move in response to changes in temperature give them a special quality: they can be bent out of shape at some low temperature in a manner resembling plastic (or unrecoverable) deformation and, when heated to a higher temperature, will speedily return to their former shape. In NiTi specimens which have nearly equal parts of titanium and nickel, the alloy can be deformed at room temperature and will spring back when put in hot tap water or when heated with a match.

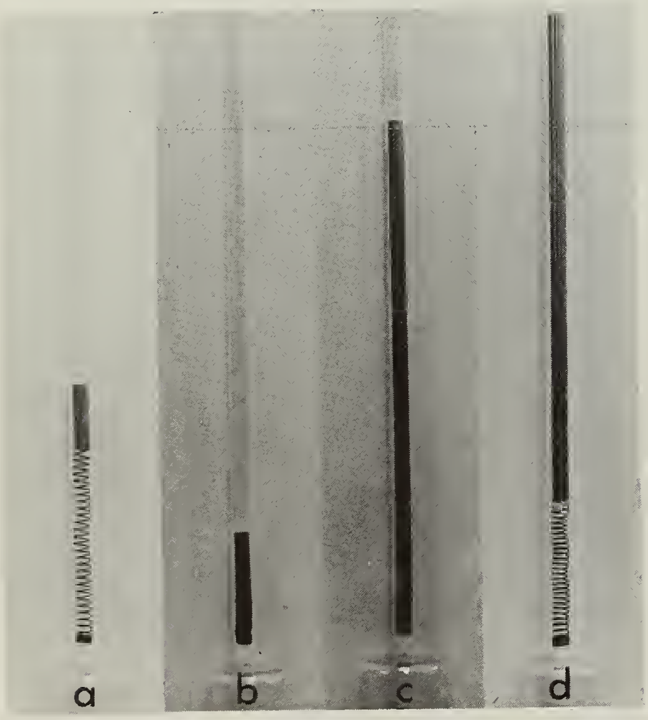
This exceptional behavior is due to a special kind of martensitic solid-to-solid phase transformation ("martensite" is the term applied to the lower-temperatured phase). Martensitic transformations are generally characterized by the ordered, coordinated pattern in which the atoms move from one solid phase to another. They always move in the same way and bear the same relationship to each other throughout the transformation. In certain alloys, such as titanium nickel, this transformation is reversible; the metal can be made to switch back and forth between two phases as often as it is appropriately heated and cooled. The temperatures at which these changes take place can also be regulated; in NiTi for example, simply by adjusting the proportion of nickel in the material.

Not all alloys have this reversible quality. Some, such as steel, harden after cooling when the martensitic transformation takes place. Wayman found that the alloy exhibited shape memory when the martensitic transformation was thermoelastic, the atom configurations were ordered, and the martensite was internally twinned (had a "pleated" atom configuration).

Wayman and his coworkers also learned that the application of heat to a shape memory alloy can cause the release of extra energy. He placed a spring made of titanium nickel in a long, narrow glass tube, and put a 20-gram weight on top of it. Cooling the spring to its martensite temperature caused the weight to collapse the spring. Wayman then added a 180-gram weight to it and heated the spring, which popped up and was able to sustain the 200 grams.

Lifting weights may not be a prime future application of the shape memory alloys, but the principles involved suggest many other possibilities. Titanium nickel is already being used as the material for pipe fittings in aircraft hydraulic systems. The composition of the alloy is juggled such that, when cooled below room temperature, it can be deformed to fit around the juncture of two pipes. As the alloy gradually warms up, its attempt to return to its original shape and size creates a tight seal which is more dependable than that of other types of fittings. This type of action has made titanium nickel effective also for dental fittings and orthodontic appliances such as braces. Wayman envisions the eventual use of shape memory alloys in medical work with hearts and heart surgery, and in the making of synthetic muscles which can be controlled externally through the use of electricity.

All in all, people stand to benefit a great deal from titanium nickel and similar alloys, whose unique properties make them clearly unforgettable. ●



This sequence of photographs shows four stages of an experiment conducted at the University of Illinois at Urbana-Champaign to illustrate the release of extra energy when heat is applied to reverse a martensitic transformation in titanium nickel. In a glass tube which was used for convenience, (a) a 20-gram weight is placed on top of a spring made of NiTi. (b) The spring, cooled by liquid nitrogen to martensite temperature, is deformed by the weight. (c) An additional weight weighing 180 grams is added. (d) When the spring is heated, the phase transformation releases enough energy to lift the 200-gram weight.

MEDALING IN ENGINEERING EDUCATION

Another engineer at the University of Illinois at Urbana-Champaign has distinguished himself as an outstanding educator, and has been honored as such by the American Society for Engineering Education (ASEE). Professor James W. Westwater, head of the UIUC Department of Chemical Engineering, was the nineteenth recipient of ASEE's Vincent Bendix Award.

In announcing the award at its eighty-second annual conference, the society described Westwater as "a world leader in the field of heat transfer." His "research, experimental techniques, analysis, and application of high-speed photography to demonstrate heat transfer have greatly advanced understanding of this process. He has produced nineteen research motion pictures and taken a leadership role in promoting research on the national level."

Westwater is the fourth UIUC faculty member to receive the Bendix Medal. Earlier recipients were Professors Nathan M. Newmark, civil engineer; John Bardeen, electrical engineer and physicist; and Harry G. Drickamer, chemical engineer. ●

THE BURNING QUESTION

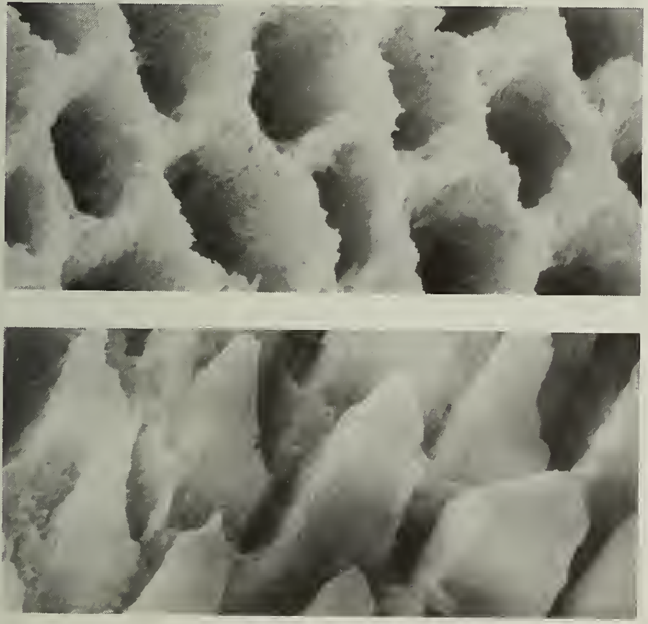
Ever since Prometheus stole it from the gods in ancient mythology, fire has held a strange fascination for most people. Engineers are not immune to this almost mystical attraction. However, three researchers at UIUC, Professors Herman Krier and John E. Prussing and graduate student Sadanand Gokhale, Department of Aeronautical and Astronautical Engineering, are watching fire with more scientific detachment than passion as they try to better understand its more destructive aspects. Their work is concerned with learning how fires spread through various types of heterogeneous materials.

In developing an analytical model Krier, Prussing, and Gokhale hope to determine the building configurations that are most susceptible to fire, how quickly a fire will spread, and how much time there is to put it out. Their predictions, based on heat transfer and mass transfer, will serve to provide a firm scientific understanding of fire propagation.

The researchers have had to deal with two main problems. One is the difficulty of doing small scale studies. Their studies, which are based on thermodynamics, cannot be simulated accurately on a small scale. The volume of fuel burning is not scaled linearly; for example, a small fire in the laboratory may ignite, burn, and extinguish itself differently from a major warehouse fire. The other problem is the fact that the volume of air passing through and sustaining the fire is so variable. The investigators hope to overcome at least part of the problem by first using many small- and medium-scale burnings — done in the laboratory on wood, cotton, and other common combustible materials — extrapolating for larger possibilities, and then testing the analytical model that results on other, different situations.

In the course of their work, which began in January, the researchers developed a basic computer model. It was designed to predict the energy transfer through multi-slab combustible material, as might be found in packaged materials. But the use of this model requires knowledge of the energy release of a specific fire source. Complicating the problem is the fact that the fire source enlarges as more and more material burns, increasing the energy release. For example, a fire burning from a pile of cotton bales stacked sixteen feet high released nine times the energy of a stack only eight feet high. The major emphasis in the study is determining how long it will take a fire to get from its burning source to the combustible stacks.

Krier, Prussing, and Gokhale are looking for some kind of pattern in burning which might help them arrive at a method of prediction. They expect their project to continue for about three more years, which means a lot of goods may be protected by a lot of ideas going up in smoke. ●



These scanning electron micrographs, which won a prize at the recent annual meeting of the American Ceramic Society, show two parts of tooth enamel, magnified 10,000 times. The sheath region (resembling a honeycomb) is as yet unidentified. The core region is made up of hydroxyapatite crystals. The regions were etched out by two different acids.

CHEWSY RESEARCH

The most rewarding research is the kind you can get your teeth into — or, if not your own teeth, then somebody else's. Professor Wendell S. Williams, opting for the latter, obtained a few specimens from his dentist and, together with graduate researcher Daniel Petty, is studying the materials science of tooth decay.

Their work centers around unraveling the mysteries of the enamel surface of teeth. It is a honeycomb-like collection of enamel prisms. The "sheath region" (outer boundaries of the prisms) and the "core region" (inner area) seem to be made of the same material, small hydroxyapatite crystals. The core region can be etched out with hydrochloric acid; but why the sheath region is not as easily dissolved by hydrochloric acid is unknown.

By applying some of the advance measurement techniques of materials science, Williams and Petty have come to some preliminary conclusions. Electron probe tests conducted on the two regions showed that their calcium-to-phosphorus ratios differed only slightly. Williams believes that this ratio has little to do with the rate of tooth decay as previously thought because, although the ratio is similar for both, it is the core region which decays first. Tests with the ion probe mass spectrometer showed no difference between the sheath and core regions in terms of type of atoms. This led the investigators to work with the hypothesis that differences between the two areas are due to structure and not to chemistry.

Williams and Petty plan to concentrate their studies more on the chemistry and physics of the hydroxyapatite mineral, hoping it will lead more directly to the solving of the mysteries surrounding teeth and their decay. Meanwhile, they still brush three times a day and hope for the best. ●

WOMENGINEERS

At the recently held twenty-fourth national convention of the Society of Women Engineers (SWE) the University of Illinois at Urbana-Champaign was shown clearly to be a force for the good in the education of women engineers. Three of the four awards presented went to its student SWE chapter, one of its engineering alumna, and one of its professors of economics.

For being designated Outstanding Student Chapter, UIUC's student SWE received a plaque and a scholarship to give to an incoming freshman woman engineering student. The student will be chosen by the chapter in consultation with the associate dean of the College of Engineering.

The 1974 Achievement Award was presented to Mrs. Barbara Crawford Johnson, a 1946 UIUC alumna in general engineering. She was cited for "significant contributions in support of manned space flight programs," notably the Apollo program.

Professor John B. Parrish, UIUC Department of Economics, was given SWE's Rodney D. Chipp Memorial Award, "in recognition of his extensive evaluation of the role of women in the professions." Parrish has dealt with the subject in a number of publications and speeches, and has participated extensively in international conferences of women engineers and scientists.

Hopefully the work of UIUC students, faculty, and alumnae will substantiate more and more the fact that women are valuable to the advancement of technology. ●

PEOPLE AND PLACES

Professor **Marvin E. Wyman**, chairman of the Nuclear Engineering Program at the University of Illinois at Urbana-Champaign, has been named a fellow of the American Nuclear Society. Wyman was recognized for "contributions to the fields of fission physics and reactor experimental techniques and for his leadership in the field of nuclear engineering education."

Professor **Frank B. Lanham**, head of the UIUC Department of Agricultural Engineering, has been presented the Massey-Ferguson gold medal by the American Society of Agricultural Engineers. He was cited for developing an outstanding staff and curriculum and establishing a doctoral degree program in agricultural engineering.

Professor **B. T. Chao** of the UIUC Department of Mechanical and Industrial Engineering and the Nuclear Engineering Program, has been elected a fellow in the American Society of Mechanical Engineers.

Professor **Charles A. Wert**, head of the UIUC Department of Metallurgy and Mining Engineering, will take a twelve-month leave from that position to fill the post of head of the metallurgy and materials section in the National Science Foundation. Professor **Carl J. Altstetter** will be acting head of the department while Wert is on leave.

Professor **Richard N. Wright**, UIUC Department of Civil Engineering, has been named director of the Center for Building Technology in the Institute for Applied Technology of the National Bureau of Standards. He has served as chief of the structures section of the center in 1971-72 and as deputy director, technical, in 1972-73.

The National Science Foundation has appointed Professor **Wendell S. Williams**, UIUC Departments of Physics and Ceramic Engineering, the new energy coordinator in its Division of Materials Research. Williams has gone to Washington, D.C., to take over the post, and is on a one-year leave from UIUC.

One of twenty-two postdoctoral research associateships awarded by the National Bureau of Standards went to UIUC graduate student **David T. Read**, Department of Physics. He will work in cryogenics, investigating strengths of materials at very low temperatures. ●

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inside outlook:

FUEL FOR FUSION REACTORS
WIND LOADING OF TORNADOES
DEFECTS IN SILICON CRYSTALS
WATER CONTENT OF GLASS

WHAT KIND OF FUEL AM I?

Good things usually come in small packages, but how good are small packages with nothing inside? If they are tiny hollow balls of hydrogen, they constitute a major step toward an unlimited supply of energy for the world. In this case the "nothing" inside is as important as the hydrogen outside.

The tiny balls, recently developed at the Charged Particle Research Laboratory of the UIUC Department of Electrical Engineering, are essential to the operation of laser fusion reactors. With them, the reactors may one day produce electricity by releasing the energy of hydrogen atoms in the focused crossfire of powerful lasers. The research is under the direction of Professor Charles D. Hendricks, Jr., Department of Electrical Engineering and the Nuclear Engineering Program. Working with him are Professor Robert J. Turnbull, also of the Department of Electrical Engineering, and physics graduate student Christopher A. Foster.

The hydrogen balls, no bigger than a grain of fine sand, are produced in the UIUC laboratory at the rate of 100,000 per second. Liquid hydrogen is squirted at a temperature of −430°F from a tube to which a 100,000 Hertz sound wave is applied. The jet is broken up into droplets, and controlled temperature and pressure together with the sound wave cause the inside of the droplets to evaporate and "blow-up" the shells of the droplets. The current work of the researchers is aimed at solidifying the droplets by freezing their shells in a low-pressure area.

Until now it had been a major problem determining how to get deuterium and tritium — the types of hydrogen used by fusion reactors — into a form that was usable without producing extra waste material. In the laser fusion reactor, the hollow particle is surrounded by laser beams, squeezing it and evaporating the outside. This increases the pressure on the particle, collapsing it to 10,000 times its normal density. The great density and temperature are what make the deuterium and tritium react to form helium, gamma rays, some neutrons, and some more tritium. If the hollow particle used as fuel in the reactor were a hydrogen-coated material rather than solidified hydrogen itself, the reactor would have waste to deal with after the reaction — if the reaction took place at all.

Fusion reactors can use the hydrogen from sea water as fuel. Ocean water is a much more plentiful resource than uranium, which is what present fission reactors must use. A gallon of sea water contains enough deuterium to produce energy equivalent to 300 gallons of gasoline. The cost of extracting the deuterium is less than one dollar and each tiny fuel ball will cost less than one cent.

The hollow hydrogen fuel, the result of two years of research at the University of Illinois at Urbana-Champaign, helps make energy from fusion reactors a safe and practical prospect for the future — which only goes to show that valuable gains can be gotten from a little fueling around. ●

SOFTENING THE BLOWS

Fairytale characters may huff and puff before blowing a house down, but tornadoes give considerably less notice before doing their demolishing. Meteorologists have developed mathematical models to determine velocity, direction, and other aspects of tornado winds; now a UIUC engineer is using this information to develop a different model, which he hopes will lead to the improved design of buildings to withstand tornado assault.

Professor Y. K. Wen, Department of Civil Engineering, plans a model that will be able to determine two things: the probability that a building will be struck by a tornado and the dynamic response of the building to its being struck. This dynamic response or oscillation of buildings due to winds is called "wind loading," and is an area in which little previous work has been done in connection with tornado studies. Tall structures, and those made with light, flexible building materials are most susceptible to oscillation.

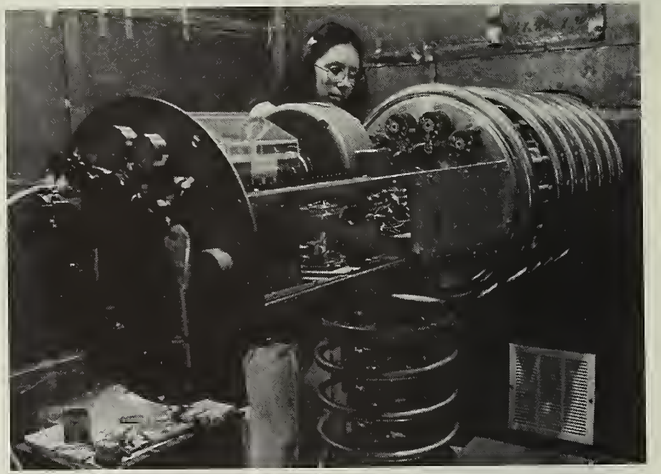
Unlike hurricanes, tornadoes act suddenly and quickly, allowing little time for buildings to be prepared for them. And in addition to wind velocity, which is the primary factor affecting buildings during hurricanes, the pressure drop and wind acceleration are the principal causes of damage sustained by structures in tornadoes. Wen discovered that predicting the acceleration of wind in a tornado is particularly important in determining the response of a structure.

Currently Wen is working on improving preliminary models, which he evolved through the use of statistics and the simplification of meteorological models of tornado behavior. After completing his computer model as currently planned, he intends to expand it also to predict the effects on buildings of gust fronts, those strong blasts of wind that occur before heavy rainstorms. It is likely that when the results of Wen's research are applied practically in the future, tornadoes may be reduced from their status as catastrophes to mere blowhards. ●

DEFECT DETECTIVES

Even at a time when everyone is eating natural foods and cultivating organic gardens, impurities have their place. Engineers in the Coordinated Science Laboratory of the University of Illinois at Urbana-Champaign have been studying them in small amounts — one kind of ion at a time — for three years.

Professor B. G. Streetman, Coordinated Science Laboratory and Department of Electrical Engineering, is conducting the project. His colleague is Conilee G. Kirkpatrick, only the second woman to receive a doctoral degree in electrical engineering from UIUC. Their research is aimed at a better understanding of how ion implantation affects silicon crystals, which are used in the making of integrated circuits for advanced electronic apparatus, as well as for radios, televisions, and similar appliances.



Conilee G. Kirkpatrick, Ph.D. candidate in electrical engineering at the University of Illinois at Urbana-Champaign, adjusts an ion implanter for use in introducing impurities into silicon crystals. The ion is accelerated through the machine and fired at the silicon sample, which is on the other side of the lead shielding.

The electrical conductivity of the silicon crystals can be regulated by putting impurities into them. Commonly this is done in two ways. Diffusion is one useful method, but it has the drawback of requiring the crystal to be heated to 1100° or 1200°C. Ion implantation, on the other hand, is accomplished by simply bombarding the surface of the crystal with impurity ions, at a speed which will force them inside. This method has a number of advantages over diffusion: it can be accomplished at a lower temperature, can be more precisely controlled, and is convenient for a greater variety of types of ions.

However, there are also limitations to the implantation technique. One of the principal ones is the radiation damage to the crystal caused by the ions banging into its surface. The usually symmetrical arrangement of atoms is jostled into disarray; the resulting irregularities in the structure of the implanted crystal are called defects. Streetman and Kirkpatrick have been looking for patterns in the rearrangement of silicon atoms after various ions have been implanted. They hope their work will lead to the ability to predict types of defects and their behavior within a silicon crystal.

To study the defects, the investigators are using photoluminescence. This process involves shining high-energy light onto the crystal, exciting the electrons to higher-than-usual energy. As the electrons encounter a defect, they return to their original condition and give off light. The light provides information about the kind of defects in the crystal. The researchers are combining this information with what they know about the implanted ion in hopes of discovering relationships and patterns.

Because their study is concerned with fundamentals, Streetman's and Kirkpatrick's results will not bring on immediate or drastic changes in integrated circuit technology. But in studies involving shooting ions into crystals, every little hit counts. ●

A GLASS OF WATER

During the making of glass, one thing that is not in the recipe always seems to get in at the melting stage: water. Two ceramic engineers at the University of Illinois at Urbana-Champaign have been studying the implications of the water content of glass. Their conclusion in most cases is: add more of it. The glass will be cheaper to make and equally useful.

For four years graduate researcher Shridhar Joshi, working with Professor S. D. Brown, Department of Ceramic Engineering, has been investigating the effects of different amounts of water on molten glass and the ease with which it can be processed. The research has had valuable implications in the face of current concerns about the conservation of energy and natural resources.

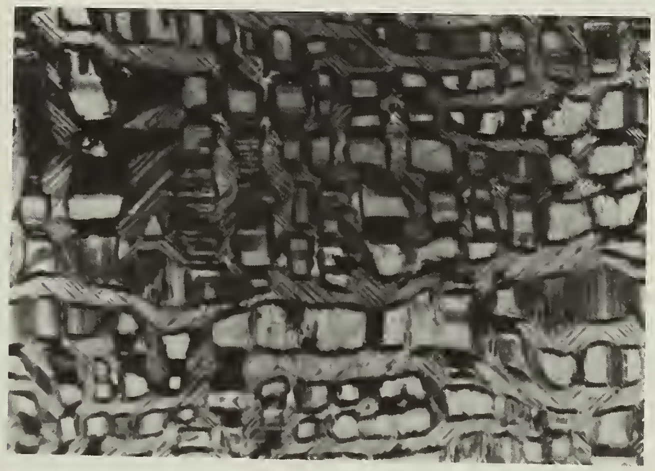
Glass is a combination of silica sand, limestone or dolomite (calcium and magnesium carbonates), soda ash, aluminum oxide, and various other additives. These are put into a glass melting furnace and heated to a temperature of about 2700°F. The resulting glass, about the consistency of corn syrup, is then formed into bottles, jars, or whatever is desired. Using water as a raw material for glass may allow the use of less soda ash, which currently is in short supply. It also can allow the glass to be made at much lower temperatures, saving energy and possibly even extending the life of the furnace.

If too much water is put in, the durability of the glass declines. The presence of carbon dioxide during the heating phase increases the likelihood of water getting into the glass, and other characteristics of the atmosphere surrounding glass during melting also have various effects on the resulting product. All of these aspects are also under study.

One unique consequence of the research has been the method Joshi developed of determining the absolute concentration of water in glass. He melts the glass ingredients, puts the glass in a crucible, and places that in a furnace in which the atmosphere can be controlled. He then introduces tritiated water (water containing a tritium ion) such that it will come in contact with the molten glass. The glass is then cooled, and the tritium, a radioactive form of hydrogen which emits a low energy beta ray, is absorbed as water and locked into the glass. After the glass is polished, a fluorescent material is put on it, which converts the beta energy into visible light. A sheet of photographic film is placed over this, exposed, and the concentration of water in the glass can be determined from the amount of exposure of the film.

Although water can play a significant part as a raw material in most types of glass, it isn't always desirable. If the glass needs good electrical properties as one of its characteristics, for example, in low loss insulators, water would be detrimental. The investigators are studying the limitations of this, and are also exploring the furnace atmosphere's effect on crystalized glass, which is used in glass ceramic products such as oven-to-table cookware.

All in all, the studies precipitated by the unavoidable presence of water in glass should have highly practical applications in the near future. At least the results will be crystal clear. ●



Thin films are the subject of a number of extensive studies at the University of Illinois at Urbana-Champaign. This transmission electron micrograph shows a thin film of an alloy of half copper and half gold, called CuAuII, magnified 100,000 times.

PEOPLE AND PLACES

An honorary degree from the University of Michigan at Ann Arbor has been conferred on **John Bardeen,** professor of electrical engineering and of physics at UIUC.

Professor **Jack A. Simon,** UIUC Department of Metallurgy and Mining Engineering, moved to the position of acting chief of the Illinois State Geological Survey from the position of assistant chief which he has held since 1973. He replaces Professor **John C. Frye,** who is retiring after twenty years as chief.

Professor **V. T. Chow,** UIUC Department of Civil Engineering, has received the Republic of China's highest award to a scientist or scholar, election to the Academia Sinica. The academy has members in mainland China, Taiwan, and a number of foreign countries. Membership, limited to less than 100, now totals 84.

Professor **M. E. Van Valkenburg,** UIUC Department of Electrical Engineering, has been named to the newly formed Commission on Human Resources of the National Research Council. He will serve a two-year term.

The UIUC Student Branch of the Society of Automotive Engineers has been recognized as an outstanding student branch by the Bendix Corporation. Eight were selected from a field of some ninety branches in the United States, Canada, and Mexico.

Professor **Barry J. Dempsey,** UIUC Department of Civil Engineering, has been named to the half-time revolving assistant deanship in the College of Engineering for the 1974–75 academic year. He succeeds Professor **Gerald P. Wirtz,** Department of Ceramic Engineering, who held the position in 1973–74.

Professor **Jerry S. Dobrovolny,** head of the UIUC Department of General Engineering, is the new president of the Illinois Society of Professional Engineers. The society, with more than 5,000 members, represents all professional engineers in the state.

Professor **John D. Haltiwanger,** associate head of the UIUC Department of Civil Engineering, was presented a "Public Service Commendation" by the U.S. Coast Guard for outstanding academic contributions and notable services in connection with the USCG Civil Engineering Support Program. ●

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COLLEGE OF ENGINEERING
VOL. 16, NO. 3, OCTOBER 1974

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inside outlook:

MINING THE OCEAN FLOOR
INCREASING PRODUCTIVITY IN CONSTRUCTION COMPANIES
NEW OFFICE OF COAL RESEARCH AND UTILIZATION
ENERGY MANAGEMENT IN VEHICLE COLLISIONS
CHEAP TWO-WAY RADIO

RESEARCHER PIPES UP

When the ocean floor is all mine, the benefits may be all yours; at least if current research into mining the ocean bottom proves it economically feasible. One UIUC engineer is contributing to research concerning the latest underwater mineral discovery: manganese nodules.

About the size of potatoes and apparently littering the bottom of the ocean, the nodules usually contain copper, nickel, and cobalt in addition to the manganese. Experiments with samples that have been brought up indicate that processing the nodules should present no serious problems. The remaining question, that of how to transport them vertically through two or three miles of pipeline to the surface, is being studied by Professor J. M. Robertson, UIUC Department of Theoretical and Applied Mechanics.

Two novel features of the study are its consideration of a vertical pipeline as the method of transport, and the large size of the particles relative to the pipe diameter. Robertson has been working on a pump concept whereby the nodules would be pumped up from the ocean floor through the pipeline in a fast-moving stream of water. The fall velocity of the particles, determined from their size and density, is a major factor in calculating how fast the water must be pumped to carry the nodules with it. Also important is the percentage of volume the particles occupy of the total volume within the pipeline.

In recent work, Robertson has been investigating particle behavior in water, using round and flat ceramic beads about the size of those used for necklaces, and round glass balls resembling marbles. The density of these experimental particles has been from two to two and a half times the density of water. While the nodules are several times that density (manganese alone is nearly five times the density of water, copper nearly nine times its density), Robertson believes that their behavior patterns can be extrapolated from the results he obtains from the experimental particles. One surprising finding was that when the particles were propelled in water upward through a pipe, they gravitated toward the sides of the pipe rather than toward the center — quite the opposite of what was expected.

Successful mining of the nodules has important applications. The U.S. currently must import 98 percent of its manganese, a necessary ingredient in the making of steel. It also imports 84 percent of its nickel and 92 percent of its cobalt. Being able to collect and retrieve these metals from the bottom of the ocean could be a big step toward allaying future shortages.

While pumping through water in a vertical pipeline has not yet been applied to mass mining of the nodules, the method has been used successfully for coal mining. Perhaps continued study of the technique will distill from the mystery of the ocean a new appreciation of the natural resources available from the earth. ●

DOING IT THE EASY WAY

Conservation, like charity, begins at home, but it may nevertheless be a difficult prospect for small businessmen. It is important for them to be able to operate efficiently, and yet many technologically advanced techniques are beyond the reach of those with little capital to invest.

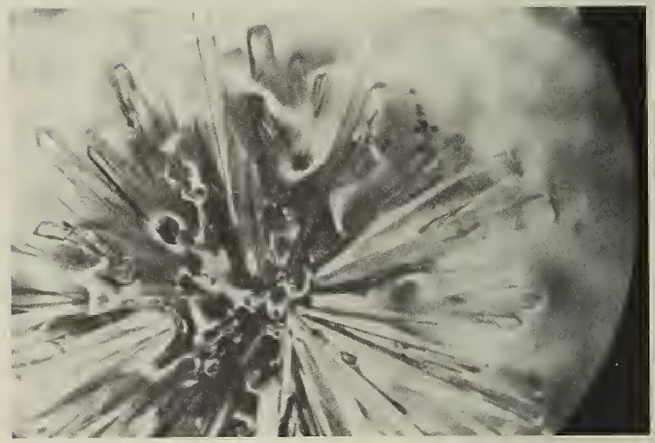
UIUC graduate researcher James Adrian, working with Professor L. T. Boyer, Department of Civil Engineering, addressed himself to the problem of increasing productivity in small companies without the necessity of great expense or extensive technical expertise. He chose to focus on the construction industry, since it has particular production problems. Most contractors are small; the average firm employs four or five people and has a net worth of less than $50,000. Past studies that have dealt with improving productivity have tended to be too academic for use by many small contractors. They also required special skills and techniques for their completion. Adrian drew on these existing studies and synthesized a new model, requiring no computer or special knowledge of any kind. It was essentially an explicit formulation of things previously done intuitively by contractors, and how they could be applied to increase productivity.

As input for Adrian's model, the contractor should first decide if he wants the maximum profit obtainable per project, or per day. This choice is based on the type and amount of work he is doing. Then an observation of work methods is conducted. It can be done by any one of the people working in the company. The observer records the time it takes to complete one cycle of operation, and makes note of the time and type of delays, using a special chart. When applied to these input data, the model provides for computation of the average delays per cycle and how much delay there is for each classification (environmental delay, equipment delay, and others). The model then helps the contractor determine whether, for example, adding a man to cut down on labor delay will add expense, cut unit cost, or both. The methods of taking notes in the field, processing the information, and evaluating the data are all included in the model.

As Adrian continues to expand the applications of his work, he expects to do a study of the conditions under which one or the other of the two objectives would be chosen by a contractor. After two years of successful work on the project, even his own model probably would not conclude that its development was a waste of time. ●

CALL UP THE RESERVES

Under Illinois soil lies one-fifth of the nation's supply of bituminous (soft) coal. That is a lot of potential energy, especially considering that coal has been mined in Illinois for 100 years and 95 percent of its supply is still under the ground. But with today's environmental concerns, the use of high-sulfur coal reserves, such as those found in Illinois, as an energy source has fallen into disfavor because such coal is not clean-burning. As energy and clean air together become precious commodities, development of this available, in fact plentiful, resource becomes even more of a perplexing problem.



Engineering research at the University of Illinois at Urbana-Champaign can be aesthetically pleasing as well as scientifically rewarding. This photomicrograph taken in the UIUC Department of Ceramic Engineering shows crystals grown from a lead diborate melt.

At the University of Illinois at Urbana-Champaign, the challenge of the situation has sparked the initiation of a number of research projects. Faculty with a high degree of knowledge and expertise in areas related to coal have been working separately and in teams. Recently, to coordinate these efforts, the University established an Office of Coal Research and Utilization. Professor James J. Stukel, Departments of Civil Engineering and of Mechanical and Industrial Engineering, was appointed as its director. The office will provide a focus for the projects that are developing and will be able to communicate more effectively with state, federal, and private organizations and educational institutions in efforts to coordinate research.

One of the new and important areas being explored is the processing, storage, and distribution of gasified coal. This is an important concept to institutions currently using gas- and oil-burning plants, because conversion of these plants to coal-fired operation is in most cases prohibitively expensive. The University's own Abbott Power Plant will serve as experimental guinea pig in these endeavors, and it is hoped that a feasible gasification facility can be built and demonstrated within about six years.

Meanwhile, at a time when choosing alternatives is an all but required facet of everyone's education, UIUC hopes to blaze new trails in a frontier which people thought they already understood: the ground they stand on. ●

A GAL, TWO GUYS, AND A GUYLESS

Three engineering students from the University of Illinois at Urbana-Champaign have won first place in the recent nationwide engineering competition sponsored annually by the Lincoln Arc Welding Foundation, Cleveland, Ohio. They received $1,000 in the undergraduate structural division for their project, "The Design of a Fifty-Ton Guyless Derrick."

The winners are Kathryn A. Davis, now a graduate student in civil engineering; Andrew M. Stefanik, a graduate student in mechanical engineering; and Marvin C. Wildenradt, employed at Dow-Corning, Midland, Michigan. The three were undergraduates in the UIUC Department of General Engineering, which also receives a prize of $300. The project was carried out under the direction of Professors Bernt O. Larson and Morris Scheinman.

This is the sixth award, and first first-place award, won in seven years in the annual Lincoln Arc Welding competitions by students in the UIUC Department of General Engineering. It was apparently one derrick that could create its own boom. ●

CRASH PROGRAM

Three UIUC engineers working together on a research project are doing a bang-up job. In fact, bang-ups are a major consideration in their study. They are developing a device for controlled dissipation of kinetic energy in vehicle collisions.

This controlled energy dissipation is termed "energy management," and is necessary to reduce damage to vehicles and minimize injury to drivers. Professors Michael H. Pleck, L. Daniel Metz, and Thomas F. Conry, UIUC Department of General Engineering, learned from preliminary studies that metal cutting was a procedure which consumed large amounts of energy. They decided to investigate how the technique might be applied to the process of safely decelerating objects in collisions.

Their research resulted in plans for a device with two main parts: an outer, hollow cylinder resembling a pipe, with cutting tools along its inner wall; and a solid metal cylinder designed barely to fit inside the pipe. The solid cylinder is partially inserted into the hollow pipe. On an automobile, the device would probably be mounted between the bumper and the car frame. Upon the car's collision with another object (moving or stationary) the solid bar would be forced inside the hollow one, and the resultant cutting of metal would dissipate the kinetic energy from the crash.

The effectiveness of the device depends, of course, upon whether its action lasts long enough to decelerate the vehicle at a sufficiently safe rate. This in turn depends upon the combined speeds and directions of the involved objects. Using what is called a "severity index," a measure of human tolerance to acceleration, the researchers developed a chart of values that correlated desired levels of deceleration and vehicle velocities to obtain stroke length. Stroke length refers to how far the solid bar must penetrate into the hollow pipe, based upon how much metal must be cut to dispose of the kinetic energy. Pleck, Metz, and Conry believe that the length of device adequate for most automobiles would be three inches. It could dissipate the kinetic energy associated with a five mile-per-hour barrier collision at a very safe severity index.

Although effective, the instrument could not be immediately applied to cars, trucks, or other conveyances because of one shortcoming: it is not automatically resettable, as the law requires. After use it would have to be manually reset to operate again. But the investigators are still working on that. As it now exists it would be useful on elevators, for protection in case the cable breaks, or possibly in situations where valuable equipment would need to be protected if it fell off a truck in transit.

Pleck, Metz, and Conry hope that continued improvement of the device will result in its being useful for many applications. For human beings it may not make accidents more enjoyable, but at least we will be alive afterwards to worry about them. ●

CHEAP TURN-ON

With costs skyrocketing in nearly every area of endeavor, the world is not so much interested in a better mousetrap as in a cheap one that works. Predictably that line of thinking doesn't apply only to mousetraps, and developing countries are frequently more in need than their developed counterparts. Tackling one of the problem areas, that of two-way radio communication in less developed countries, are UIUC Professor C. D. Hendricks, Department of Electrical Engineering and the Nuclear Engineering Program, and electrical engineering graduate researcher Douglass Wilner.

Hendricks had studied the medical problems of Indonesia and other developing countries, and found that one of their chief problems was making sure medical help was in the right place at the right time. Communication was poor between towns, and adequate communications equipment was too expensive to purchase. Hendricks decided to develop a cheap two-way radio system. Now, a year later, fifteen of the units will be undergoing preliminary testing in Nicaragua.

The work began with consideration of which characteristics would be absolutely necessary in an inexpensive two-way radio and which would be extraneous. It was important that the radio be made simple enough to be operated by electronically unskilled people. High quality materials were necessary, but compactness, sophistication, and beauty were not. Hendricks and Wilner found inexpensive materials that would do the job well and devised circuitry that was not as foolproof as that in commercial units, but would nevertheless stand up to use by a semiskilled operator. In fact, the unit is easier for the layman to operate than a commercial one, because there are not so many specialized functions.

In terms of broadcasting and receiving versatility, Hendricks and Wilner decided that if the radio operated on only one frequency and were restricted to a 100-mile range, it would be considerably less expensive. Seven megahertz became the chosen frequency, since it was used for health communications in at least one of the countries and required relatively little power to operate. This also solved the anticipated problem of extensive power drain on the batteries. A final difficulty neatly solved by some investigative digging was the choice of antenna; the half-wave dipole is cheap to make and easy to install, and its lack of superior directional qualities proves to be no deficiency in this particular application.

In their work the researchers' primary aim was to keep costs down. The usual cost for a two-way radio unit is from $300 to $500. Hendricks's and Wilner's model, if made in reasonable quantities, costs $75.

Success is anticipated for the fifteen units soon to be operating experimentally in Nicaragua. If all goes well, they can be produced in greater quantities and sold to those countries that need them. In this case beauty isn't even skin deep but, refreshingly, nobody cares. ●

PEOPLE AND PLACES

Professor **B. A. Jones, Jr.**, UIUC Department of Agricultural Engineering and associate director, Agricultural Experiment Station, and **Ralph C. Hay**, professor emeritus of agricultural engineering, have been named consultants to the Subcommittee on Drainage Districts, Water Pollution and Water Resources Commission, Illinois State Legislature.

UIUC alumnus **Herbert A. Schulke, Jr.**, will leave his post of director of communications electronics in the Joint Chiefs of Staff of the United States to become general manager of the Institute of Electrical and Electronics Engineers (IEEE). Schulke earned his M.S. and Ph.D. degrees in electrical engineering from UIUC.

The National Aeronautics and Space Administration (NASA) presented the Skylab Achievement Award and Skylab Medallion to UIUC Professor **Harlow W. Ades**, Departments of Physiology and Biophysics and of Electrical Engineering. He was cited for his "most valuable contributions to the life sciences aspects of the Skylab Program." ●

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UNIVERSITY OF ILLINOIS BULLETIN
COLLEGE OF ENGINEERING
VOL 16, NO. 4, NOVEMBER 1974

inside outlook:

INCREASING EFFICIENCY IN NUCLEAR POWER PLANTS
IMPROVING RAILROAD WHEEL DESIGN
RECYCLING CONCRETE AS CEMENT
STRATIFIED CHARGE ENGINE FOR AUTOMOBILES
CERAMIC COATING OF METAL FOR LONGER WEAR

GOIN' FISSION

The energy crunch has caused a lot of reactions, not the least of which has been an interest in reactors. As utilities try to reduce their reliance on oil, nuclear power plants emerge as an important alternative. Currently, however, the plants supply only 5 percent of all the electricity generated in this country. Nuclear engineers are seeking an economical way to increase the share to 50 percent, but as they exist now the nuclear power plants are not unconditionally capable of safely increasing their output. UIUC Professor R. A. Axford of the Nuclear Engineering Program is studying how to keep one troublesome product of nuclear fission reactions from hindering future reactions and limiting the efficiency of reactors.

Fission reactors use uranium as fuel and must have a high density of available neutrons to operate. When the uranium reacts with a neutron, a type of xenon gas known as Xe-135 is produced either directly or indirectly, and remains in the fuel chamber with the uranium. Xe-135 has a tendency to absorb neutrons, which causes the flux level (concentration of neutrons) to decrease. To burn out the Xe-135, the flux level must be increased; yet as it increases, more Xe-135 is produced. Before the process terminates, xenon instability could result, melting the uranium. Xenon burnout can also result in small "hot spots" of more-than-usual fissions within the fuel chamber, increasing heat. These hot spots can spread around the chamber, also allowing greater possibility of melting the uranium. Current fission reactors are kept safe by being allowed to operate only at levels where instability and melting won't occur; but they are not fully economical. In addition, reactors are designed to have enough extra fuel to restart after being shut down, but may be prevented from immediately doing so by xenon's consumption of neutrons. Axford's project is aimed at solving the problems of xenon instability so that the efficiency of nuclear power plants can be increased.

In order to arrive at the optimal solutions he needs, Axford is doing a mathematical analysis incorporating some techniques of modern optimum control theory. The analysis will help to define reactor sizes and parameters which are inherently safe and will help nuclear engineers to discover how instability problems can be minimized so that bigger reactors with higher power ratings can be built and operated safely. Data on the structure of all the materials involved in a nuclear fission reaction is used as input for the computer, and the problems are formulated so that the computer can come up with an optimal solution. Axford is handling more difficult aspects of the problem than have formerly been dealt with, so although portions of the problem have been solved, there is still more work to be done.

Axford is also providing mathematical analysis by which an automatic control system can be designed. This would replace the human operators who now must monitor the reactors and manually introduce controls into the system.

An important advantage of this research is that it will result in an economical source of power. That is one thing even the most nontechnical of us will be able to turn on to. ●

BRAKING WITHOUT BREAKING

Consider the railroad wheel. While guiding an ordinary loaded freight train down the track, it may support as much as 30,000 pounds — the weight of ten automobiles. During a severe application of the brakes, the temperature may reach 700°C between the brake shoe and the wheel. Even so, most railroad wheels run about 200,000 miles before wearing out. That's not bad when compared with the 25,000-mile lifespan of an average automobile tire.

The performance of these wheels are of interest not only to railroad engineers, but also to engineers at the UIUC College of Engineering. Of particular concern is the dissipation of the heat generated during braking. Professor H. R. Wetenkamp, Department of Theoretical and Applied Mechanics, is studying ways of redesigning railroad car wheels to withstand severe braking a greater number of times.

The railroad wheel has two main parts: the central, circular part, called the plate, and the outer edge, or rim. The heat generated from the brake shoe being applied to the rim causes the rim to try to expand. The plate of the wheel, however, is still cool, so it pulls on the rim, causing compression. As a result the rim deforms inelastically. As the rim cools it tries to shrink to a smaller-than-original size; this time the plate, rather than pulling on the rim, is pushing against it, building up tension. If severe brake application is carried to an extreme, the wheel could blow up.

Wetenkamp is working on reducing this compression-tension problem through changing the shape of the wheel. He has been investigating different types to determine the characteristics necessary in an optimum shape. His main aim is developing a wheel with maximum flexibility that will still carry the required load; a heavy wheel would be too rigid to allow for the necessary expansion. He also found that using a thick rim, though it wears well and keeps the temperature down, causes more compression and tension.

Engineers in a number of countries have made gradual improvements in railroad wheels over the years. Wetenkamp has learned, however, that as the wheel is improved, men put more load on it and run it at higher speeds, complicating the problem of further improvements.

Wetenkamp's extensive studies have resulted in a tentative new wheel design which redistributes more uniformly the same amount of material currently used in railroad wheels. He is considering doing work on the brake shoe to see if there is a way to make it distribute heat more uniformly as well.

As costs of transporting freight continue to rise, Wetenkamp sees railroads as becoming a more important mode of transportation than any other because of its economy. When he is ready to offer the results of his research to commercial concerns for consideration, it should prove to be one of the more welcome cases of wheel-dealing. ●

LAY IT AGAIN, SAM

Most of us don't have a lot to do with concrete in the first place, but doing something with it the second time around is a problem even for construction engineers. Old, unused concrete at building sites contributes considerably to the solid waste problem. Joel Smason, senior in civil engineering, had an idea for dealing with the problem. During this past summer, under the direction of Professor J. Francis Young, he decided to investigate recycling concrete rubble to be used again as cement.

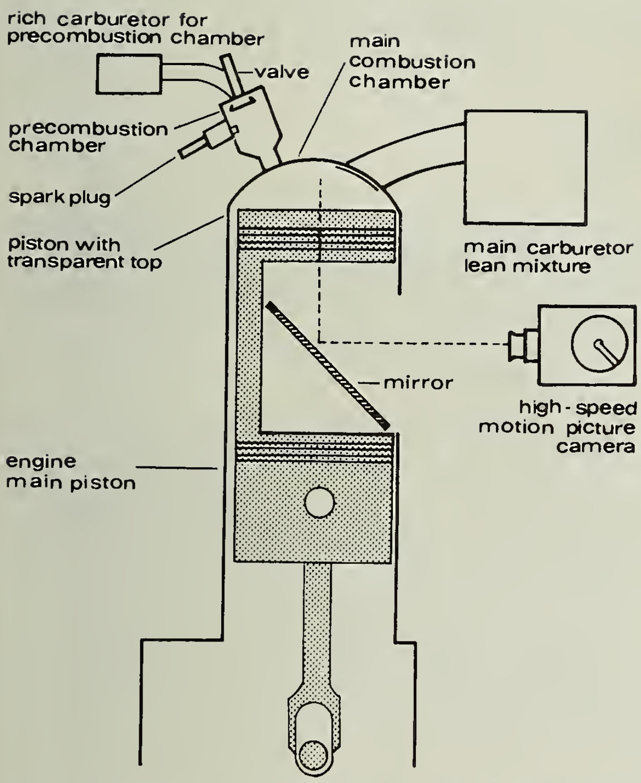
Concrete is a mixture of cement, sand, and gravel. Cement is the bonding agent used to hold the elements of concrete together. It is usually made of limestone and clay fired in a kiln at temperatures between 2700° and 3000°F. Smason planned to crush the concrete rubble and mix and heat it again to turn it into cement. He `had a few more problems with the project than he anticipated.

Both Smason and Young believed that sodium, potassium, and magnesium — three trace elements found in concrete — would prove to be a problem in making their recycled cement reusable. The occurrence of these three elements is kept limited by specifications because they lead to problems in the strength and life span of the concrete. But the researchers found that, within the limits of their study at least, the elements would not be present in excessive quantities.

Smason's biggest problem as a civil engineer was doing the necessary chemical analysis of the leftover concrete material, and determining the adjustments that had to be made; it was usually necessary to add lime. Also, making the cement from the concrete rubble proved to be difficult because equipment had to be somewhat improvised. But he completed his project in about four months.

Smason and Young agree that the next step in testing the feasibility of the idea would be to run pilot studies in a cement plant. Whether or not the use of the recycled rubble would be economical has not been determined. The main problem anticipated is that, though the rubble would supplement the usual raw materials used by a cement plant, a place would have to be found to store it, and an extra input to the kiln would have to be installed for its processing. These mean extra expense for the cement company. There are other variables involved too, such as the cost of transporting the rubble to the plant.

As an environmental concern, however, the plan has definite possibilities. Smason is in the process of completing his report, after which he will move on to other investigations — leaving his footprint in the wet cement of engineering history. ●


rich carburetor for precombustion chamber
valve
main combustion chamber
precombustion chamber
spark plug
piston with transparent top
main carburetor lean mixture
mirror
high-speed motion picture camera
engine main piston

This is a drawing of an experimental engine being built by mechanical engineers at the University of Illinois at Urbana-Champaign. The main combustion chamber, instead of being sparked directly, is ignited by a rich fuel-air mixture burning in a small precombustion chamber. This allows a leaner mixture to be used as fuel and still burn well. The engineers are studying the igniting and burning processes by taking high-speed movies of them as reflected in a mirror placed in a cutaway section of the piston.

EMISSIONARIES

With most endeavors you get out what you put in, but two UIUC engineers hope to get a lot less than usual out of their endeavor when it is completed. Their project is a new kind of engine for automobiles that will give high fuel economy but will produce a much lower quantity of polluting emissions than current automobiles produce.

The fuel burned in a normal automobile engine is a rather uniform blend of gasoline and air that is mixed in the carburetor. The imperfect burning of this fuel results in hydrocarbons, carbon monoxide, and nitric oxides being emitted into the air. The amount of these discharges can be somewhat controlled by regulation of the carburetor. If it is adjusted to "run rich," allowing a little more gasoline in the mixture, more hydrocarbons and carbon monoxide are emitted. If it is adjusted to "run lean," allowing more air in the mixture, the nitric oxide emissions increase. There is a point at which a lean-running engine would have very low emission of all three pollutants, but car engines as they are currently designed run very poorly, to the point of impracticality, at this level.

A diesel engine, which is designed differently, is capable of running lean to a much greater degree than a car engine, making it one of the most efficient and least polluting engines on the road. Diesel trucks are believed to belch great quantities of smoke and soot into the air, but actually this rarely happens because of the engine's efficiency. It is a type of "stratified charge" engine, stratified because different mixtures of fuel and air are used in different parts of the engine. This results in better fuel burning and considerably less hydrocarbon and carbon monoxide emission, even though it smells worse.

Professors S. C. Sorenson and W. L. Hull, Department of Mechanical and Industrial Engineering, are working on a gasoline engine that operates in a way similar to a diesel engine. Their engine will have two carburetors, one small and one large, feeding two combustion chambers inside the engine. The large carburetor will be designed to provide a lean mixture for burning in the main combustion chamber. To improve the efficiency of the burning of this mixture, a rich fuel mixture in the smaller precombustion chamber will burn first and ignite the lean mixture, giving it a boost. This will result in very low emissions and acceptable engine performance. The primary goal is to increase fuel economy, but in designing the engine to do so, the researchers expect that emissions also can be kept to a minimum. In addition to building experimental engines, they plan eventually to develop a computer model to optimize fuel economy and performance in the engine.

Sorenson and Hull will use an unusual technique for studying the ignition and burning of fuel in their new engine. By building one engine somewhat taller than usual, they will have room to insert a slanted mirror beneath the combustion section of the engine, in a cutaway section of the piston area. The piston will be fitted with a transparent top. Using a high-speed motion picture camera aimed at the mirror, they will take movies of the combustion process, and use the information to figure out adjustments and improvements.

Auto companies have shown interest in this type of engine which, when perfected, will make add-on emission control equipment unnecessary and will provide good performance as well. Sorenson and Hull are enthusiastic about their particular investigation, and apparently have what it takes — a lot of drive — to make it successful. ●

CERAMIC PUT-ON

It is usually true that engineers stick to their research, but one project being conducted by two UIUC investigators is doing some sticking of its own. The result is improved wear characteristics for such things as disc brakes and pistons in automobiles, and cutting tools used in factories.

The new process is a method of attaching a thin film of hard, wear-resistant ceramic material to a strong, flexible metal. Thin films have been studied extensively in the past for their electrical properties, but their mechanical properties and related applications have seldom been considered. At the University of Illinois at Urbana-Champaign, J. E. Greene, assistant professor of industrial engineering and metallurgical engineering, is working together with Harry E. Cook, associate professor of metallurgy and mechanical engineering, to explore this new area.

In cutting tools, which are subjected to constant wear, the surface of the tool must be hard but the metal used to make it has to be bendable so that it does not chip. Ceramics are wear-resistant but brittle; metals are bendable but soft. Greene and Cook believed that if a very thin layer of hard ceramic film — much less than the thickness of a hair — were applied to the surface of the metal tools, it would not adversely affect bendability but would increase the hardness of the surface. Titanium carbide (TiC) has good qualities for the wear-resistant layer, and steel is the usual tool metal used, so the researchers worked with these.

One method which has been used to attach the ceramic film is chemical vapor deposition, which requires heating to a temperature of about 1200°C to complete; for this reason it has proved inconvenient. Evaporation is another coating method; the material is wrapped with a coil through which an electric current is passed. But this cannot work with TiC because its melting point is higher than that of any material used for the coil.

The procedure evolved by Greene and Cook is easier than the other two and results in very high adhesion of the TiC to the surface of the metal. Both TiC and a metal object, such as a cutting tool, are placed inside a cylindrical glass enclosure and electrically connected. The pressure inside is reduced by pumping, and the near-vacuum is filled with argon gas. Radio frequency power is then applied to the electrodes, causing the argon gas to ionize. This process accelerates the argon ions against the TiC crystal, knocking out titanium and carbon atoms which adhere to the metal surface. The researchers have found the process economically feasible for the future, because the cost of the small amount of TiC used in coating the metal will be more than made up for by longer tool life.

After spending a year and a half on this project, Greene and Cook plan to expand their work on the applications of this method. One idea is to create a coating alternating tiny "pockets" of TiC with pockets of a kind of plastic currently used to prevent sticking in cooking utensils. This coating could be used where long wear and low friction are desired, such as in automobile pistons.

As research continues, ceramic thin films may be the factor that will allow metals to be adapted to all kinds of uses, a ceramic overcoat that will lead to under-wear. ●

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COLLEGE OF ENGINEERING
NO. 5, DECEMBER 1974

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inside outlook:

STUDYING MATTER USING HIGH PRESSURE
ATOMIC EXPLORATION OF CRYSTAL SURFACES
NEW UIUC DESIGN AWARD ESTABLISHED
GRANT SHARED BY THREE UIUC DEPARTMENTS
MICROBIAL GROWTHS IN WATER DISTRIBUTION SYSTEMS

HIGH PRESSURE TACTICS

When not concerned with the social implications of high pressure, many people think of it as the method of making diamonds out of graphite. But this is little more than a passing thought, even to engineers who work with pressure studies. For them it has more practical, and in some cases more fascinating, applications.

The use of high pressure alters the structure of many materials, changing what were once insulators into metals, for example, or converting certain metals into semiconductors. When temperature is increased along with pressure, additional modifications take place. A chemical engineer at the University of Illinois at Urbana-Champaign has been applying very high pressures to a number of materials to study the nature of their structures and how they change, hoping to learn more about their behavior.

Such things as the color of materials and their ability to conduct electricity are controlled by the energy level of their electrons. At a particular level of pressure — for example, normal atmospheric pressure, which is measured as one atmosphere — electrons tend to remain in an arrangement in which the least energy is demanded of them; this is called the ground state. The amount of space between the energy levels and the number of electrons in each level of a material determine whether the material is an insulator (wide space), a semiconductor, or a conductor (where electrons within a level are free to move). Under conditions of high pressure, the spacing between levels changes and electrons often "hop" across the spaces into higher energy levels. If the pressure is great enough, they settle into a new ground state different from the one they maintain at one atmosphere pressure. This new ground state often has different properties from the original ground state. Both the volume of the material and the amount of energy needed to excite the electron are affected. At pressures of 150,000 atmospheres, for example, iodine, which is an insulator, becomes a metal. Calcium, which is a metal under the ordinary pressure of one atmosphere, becomes a semiconductor under high pressures.

Professor Harry G. Drickamer, UIUC Department of Chemical Engineering, has been experimenting with these materials to see what happens to their energy levels relative to their environment when pressure is increased. The pressures he is using in his investigation are from 50,000 to 500,000 atmospheres. He wants to understand what makes the energy of one material shift more than that of another. One of the main processes he is using involves shining light on electrons, observing what happens when they are excited into higher energy levels, and examining how the electrons act under particular changes in pressure. Since pressure is the only variable in his experiments, he is able to gauge its effect on the way materials behave.

As a result of his work, Drickamer believes that in many cases new ground states which can be reached by changes in pressure may also be reached through changes in the composition of the materials. In such cases desirable characteristics of an ordinary material when under very high pressure may be replicated by changing the composition of the material so that it has the same characteristics at the normal pressure of one atmosphere. Increased comprehension of the structure of the materials and their electronic properties may make it possible to use this knowledge to change the way the materials behave under normal conditions. Applications range from better catalysts for more efficient chemical reactions, better optical materials, and improved types of glass to a better understanding of such biological effects as the breakdown of protein structures.

Drickamer's future research, in addition to studying further the possibilities of composition change, will also continue his current analysis of behavior extended to more materials. It may be that pressure may lead them, as it does their human counterparts, to behave as we want them to. ●

THE PLANE TRUTH

The surface of an object would seem to be where its intricacies stop and its environment begins; yet engineers find interesting phenomena on surfaces as well as in what is underneath them.

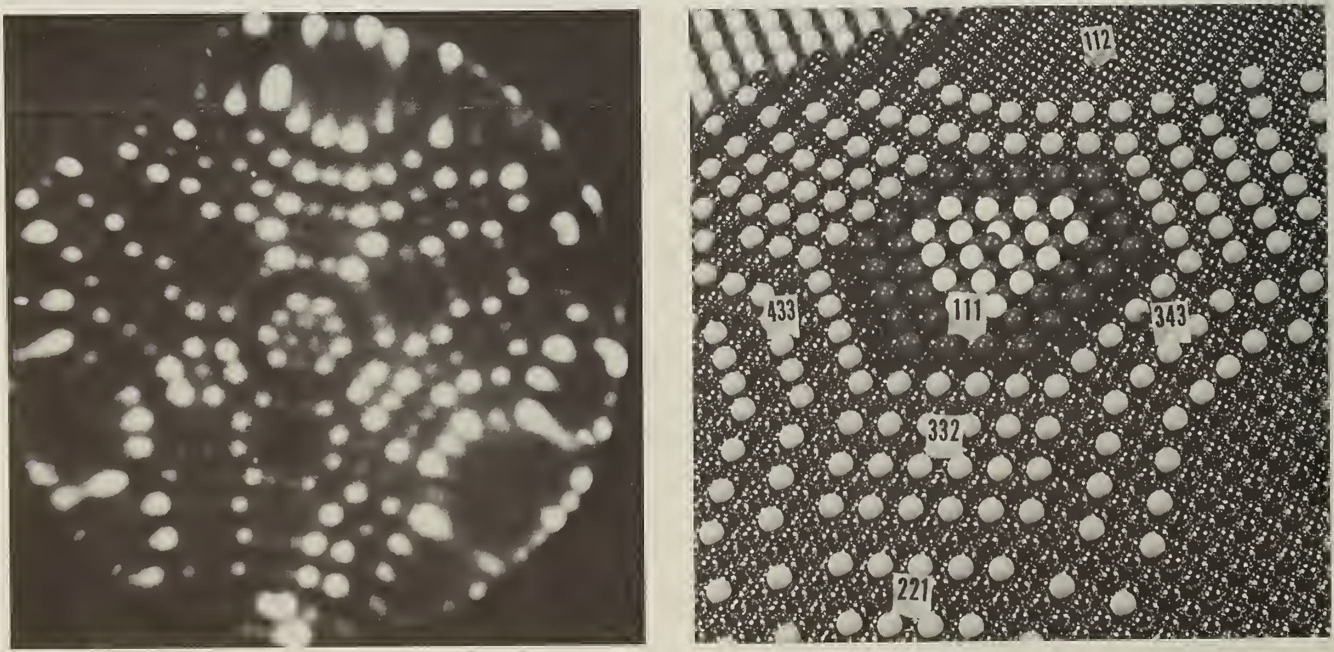
In solid-state devices, for example, surface layers are becoming increasingly important. They are usually only a few atomic layers thick. Knowledge of the behavior of atoms that are evaporated onto their surfaces will eventually be significant for improving their performance in various applications. Until the development of the low-temperature field ion microscope, this behavior could only be guessed at. A group of engineers at the University of Illinois at Urbana-Champaign, however, is now using this instrument to observe and photograph individual atoms and their patterns of movement on crystals.

Crystal surfaces are planes of perfectly symmetrical atom arrangements. Some of the "holes" or spaces between the atoms are deep, and some are shallow. Professors Gert Ehrlich, W. R. Graham, and graduate researcher David A. Reed, all of the UIUC Coordinated Science Laboratory and the Department of Metallurgy and Mining Engineering, have been using the field ion microscope to visualize individual atoms on crystals. The researchers have been able to watch where atoms "land" when evaporated onto the planes of crystal surfaces and where they are held; they have also been able to learn where and how quickly atoms move under various conditions and what surface features influence motion. By comparing this with their hypotheses, they hope to learn more about the structure of crystal surfaces and the effect it has on atomic behavior.

Their research has brought to light a number of unexpected results. They have found that most of those atoms evaporated onto the crystal tend to sit in deep holes, as might have been expected by anyone who has watched a child play with marbles. Surprisingly, however, a significant fraction — 5 percent — sit in shallow holes, which is unusual. Also, those planes on which the speed of an individual atom's movement is actually found to be the greatest differ from the areas on which a hard sphere such as a marble would show the greatest speed. Ehrlich, Graham, and Reed believe that surrounding atoms on the surface may have as much effect on a particular atom's movement as the crystal surface itself. They have been able to study the interaction between two individual atoms, and the effects of this interaction on the movement of atom pairs on a surface.

Solid-state electronics and many other technologies stand to benefit from a better understanding of surface behavior. Ehrlich, Graham, and Reed hope that their research will help to make this crystal clear. ●

The bright spots in the photograph on the left are atoms, magnified ten million times, that make up the top layer of a crystal surface. The photo was taken through a field ion microscope at the University of Illinois at Urbana-Champaign, where engineers are investigating atomic behavior on crystal surfaces. Note how the patterns in the photo correspond to those of the crystal surface model on the right.



DESIGNS ON DESIGN

A new award for engineering design has been established by the UIUC Department of General Engineering, and is named for a professor who has made outstanding contributions to the development of integrated engineering design education.

The Bernt O. Larson Project Design Award in General Engineering will be presented annually to the senior student project design team that produces the best engineering design during the year. The award honors Larson on his retirement, in recognition of his 37 years of service to the University.

In the past seven years, student project designs by UIUC general engineering students have been submitted for national competition in the James F. Lincoln Arc Welding Foundation Award Program for Progress in Engineering Design. They have received awards six out of the seven years; Larson was the faculty adviser to four of the six winning teams.

The first award will be given in the spring of 1975. From then on, though he has retired, Larson's name will be continually associated with the outstanding results of engineering design education. ●

DIVIDING BY THREE

The UIUC Departments of Chemical, Electrical, and Mechanical and Industrial Engineering have received the majority of $24,000 in grants given to the University of Illinois at Urbana-Champaign by the Eastman Kodak Company.

The money was given for graduate education and research at the doctoral level, or for new and improved facilities. UIUC is one of forty institutions in which selected departments received research grants. Perhaps provisions for adequate facilities may mean living in the lab of luxury is not far off. ●

IN THE MAIN

In the same way that a power failure can strand you without candles, rusty red water coming out of the faucet can make you suddenly wonder about things you formerly accepted without question, like the water pipes. Engineers themselves have been puzzled about what causes quality changes in water between the treatment plant and the home faucet. Additives calculated to prevent the corrosion of the iron pipes by the water flowing through them did not stop periodic complaints by consumers of red water and strange odors and tastes. Professor John T. O'Connor, UIUC Department of Civil Engineering, hypothesized that the water in most cases did not come in contact with the pipe walls but was separated from them by bacterial growths which periodically accumulated and were dislodged. He began, along with graduate researchers Mark H. Schneider and Sai Lee, to investigate the possibility that these organisms were the cause of the problems within the water distribution system.

Two discoveries which originally suggested that the organisms might be present were that, in many water systems, the further away from the treatment plant the water traveled, the less chlorine and oxygen were found in it. The depletion of oxygen could be accounted for by the presence of oxygen-consuming bacteria, the loss of chlorine by reactions perpetrated by sulfate-reducing bacteria. As the study was pursued, connections were discovered between the life cycles of such bacteria and their manifestations in the bathroom or kitchen sink. "Off-tastes," often associated with stagnant water, are actually the result of bacterial decomposition. The "rotten egg" odor, which becomes apparent only when water is heated, is a result of sulfates in the water being reduced to hydrogen sulfide by sulfate-reducing bacteria. Red water is also a result of the action of these bacteria; the reduction of sulfate frees electrons which increase the oxidation (rust) of iron. Even a limited amount of sulfate reduction can visibly influence the color of the water.

A thin film of bacterial growth can be helpful in retarding corrosion, because it can keep oxygen concentrations down, and can prevent the diffusion of dissolved iron into the water. But when a thick layer of organisms separates the pipe wall from the water, increased alkalinity of the water and the addition of lime — both designed to reduce corrosion — have no effect on the pipe.

In water distribution systems built within the last ten years, pipes have been lined with cement or tar, significantly reducing the possibility that these problems will occur. But replacing other systems with the same type of pipes would be prohibitively expensive and difficult.

O'Connor, Schneider, and Lee believe that an effective way of dealing with the problem would be to treat water at the plant in such a way that the organic content will be reduced. Exactly which materials it would be most expedient to remove could be determined through testing. The organisms could then be made to grow in water treatment units outside the water distribution system, allowed to slough off, and removed from the water before it entered the system.

While these bacterial growths are harmless, the results of their activity can sometimes make water look, taste, and smell worse than it actually is. Undoubtedly, the work of O'Connor and his colleagues will be more than a rusty drop in the bucket toward improvement. ●

NOW IT'S ALL OVER FOR WOMEN

It is called *WOMENGINEER*, and it is a reprint of a prize-winning booklet prepared by the UIUC Engineering Publications Office.

The publication informing women about opportunities in engineering won a Certificate of Merit from the American College Public Relations Association. Under a $10,000 grant from E.I. du Pont de Nemours and Company, the Engineers' Council for Professional Development (ECPD) reprinted 40,000 copies for high school mathematics and science teachers throughout the United States, and for guidance conferences.

Copies may be obtained from ECPD, 345 E. 47th St., New York, New York 10017. ●

PEOPLE AND PLACES

Professor **Ven Te Chow**, UIUC Department of Civil Engineering, visited mainland China as a member of an eleven-man United States delegation to observe water resources development and engineering education there.

Professor **C. T. Sah**, UIUC Departments of Electrical Engineering and of Physics, will receive in February an honorary doctorate degree from the Catholic University of Louvain, Belgium. The award, which has not been given to a scientist for ten years, recognizes Sah's contributions in the fields of semiconductor physics and solid state electronics. ●

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inside outlook:

CRUDE PROTEIN FROM INDUSTRIAL WASTEWATER
SYSTEMS ANALYSIS APPLIED TO CRIMINAL JUSTICE
GRANTS FOR BIOENGINEERING AND METALS RESEARCH
BIOENGINEERING TEAM TO WORK WITH HOSPITALS
PLASMA DISPLAY PANEL AS TELEVISION SCREEN

SOMETHING OUT OF NOTHING?

To those who have to deal with it, waste material isn't exactly a "nothing" product, but it isn't always obvious what can be done with it. Getting rid of it is what occurs to most people, but environmental engineers are the type that hope to gain something while accomplishing disposal. A number of ideas for the productive use of wastewaters have been proposed, and now graduate researcher Gulerman Surucu, under the direction of Professors R. S. Engelbrecht and E. S. K. Chian, UIUC Department of Civil Engineering, has another idea. He wants to redeem protein in the form of bacterial cells from high-carbohydrate industrial wastes so that it can be used wherever a crude source of protein is needed, such as in animal feed.

Biological treatment using bacteria is often employed to remove organic pollutants from wastewater. Most treatment systems are operated near room temperature (in the "mesophilic range"). Some systems can be operated with another type of bacteria called thermophiles which prefer a higher temperature; however, these usually cannot be used because most industrial wastewaters are of a type that cannot supply or support this high temperature. Surucu decided to use thermophilic bacteria to treat wastewater with high organic matter content, such as that of a dairy or cheese-making plant or the wastes from starch or corn processing. If they worked well, the use of thermophilic processes could make waste treatment proceed faster allowing for the use of generally smaller waste processing facilities at these types of plants.

Surucu conducted his research in the laboratory by first isolating the bacteria from soil and several other sources. He then reacted them with a synthetic high-organic waste material he had created. The results turned out to be successful; the remaining high-protein matter, if dried, processed, and packaged, could be used as a source of crude protein.

The next step, which Surucu is now working on, is to determine the economics of the process. If these turn out to be practical, there will be yet another opportunity for the waste of society to be rehabilitated. ●

INSURING THE RIGHT TO A SPEEDY TRIAL

Professors and research people in an academic setting are sometimes accused of not maintaining contact with the "real world" their research is supposed to benefit. In the case of engineers it is usually the real world that provides them with practical problems to solve, so their work, if not immediately applicable, at least sheds some valuable light on a problematic area.

In many situations, the researchers have to gather their data by spending a sizable amount of time watching the problem in action. That is what UIUC Professors Richard E. DeVor and Gary L. Hogg, along with their graduate students, were doing for a month while sitting in on operations of the Champaign County criminal justice system. In conjunction with the National Clearinghouse for Criminal Justice, Planning, and Architecture, they have worked on the theoretical aspects of improving criminal justice operations through systems analysis procedures. Now the two engineers from the Department of Mechanical and Industrial Engineering are applying these procedures, in another clearinghouse project, to the specifics of the local system.

DeVor and Hogg examined the available data as thoroughly as they could, observing scheduling procedures, measuring relative and absolute amounts of time it took for people to get through the different stages of the system, interviewing judges and attorneys on how the system operates, and checking through case files. From these they categorized crimes, prepared statistics, developed a network model of the system, and coded it so that it could be fed into a computer. This modeling technique, which utilizes a special language called Generalized Network Simulator (GNS), was developed by them to reduce the amount of computer programming necessary. The model helps them to identify problem areas and test alternative solutions. This is preferable to experimenting with the actual system, which is impossible due to the legal and sociological implications involved.

DeVor and Hogg have so far been able to make valuable suggestions to Champaign County as to what current buildings are still efficiently usable, what new buildings should be built, and how best to deal with certain scheduling difficulties. Future decisions will concern the efficiency and economic feasibility of night court, how judges can best schedule trials to make use of the jurors available, and what programs could be developed that would help improve the existing system.

The work of these two systems analysts has important implications in areas other than system efficiency. For one thing it should help keep tempers down — after all, no matter what it's for, no one likes to stand in line. ●

FIRST AID

A $45,000 grant has been given to the University of Illinois at Urbana-Champaign by the National Institutes of Health for doctoral training in bioengineering. It is the first financial aid for graduate training in bioengineering received by the University, and will assist four or five students and help provide facilities.

Bioengineering in its many aspects spans a number of engineering departments at UIUC. The grant will make it possible for bioengineering to expand its effect on many types of current and future research. ●

THE BEST IS YET TO COME

When one thinks of teams, one usually thinks of impending competition, but nothing could be further from the minds of the bioengineering faculty at the University of Illinois at Urbana-Champaign. They are working together with the Regional Health Resources Center (RHRC) in Urbana to create a Biomedical Engineering Systems Team (BEST) for providing engineering and other technical services to hospitals and clinics in east central Illinois.

What began as a feasibility study by Professor John C. Chato, co-chairman of the UIUC bioengineering faculty, became an actual project when the RHRC demonstrated an eagerness to work on it. Now Chato co-directs the team with the executive director of the center, with the aid of a grant from the Illinois Regional Medical Program. It is one of about fifteen teams in the United States now in operation or being formed.

The team plans to work with participating hospitals and clinics in order to allow them to improve their services, provide services more regularly, and to do so with cost effectiveness. The basic idea of the cooperative program is to develop a complete engineering service in all medical areas where it is needed by hospitals. In its consultative role the team will, for example, help reduce equipment breakdown, help in choosing appropriate new equipment, and generally aid in technical areas. They will be approaching these areas, however, from a medical orientation rather than a physical plant emphasis.

Chato and his colleagues started their program by evaluating the types of work needed by hospitals. From this they will establish the areas they want to begin work on, and then will train people who will perform the services needed and assist hospital employees in these areas. These trained personnel will be available to all the participating institutions in need of their services.

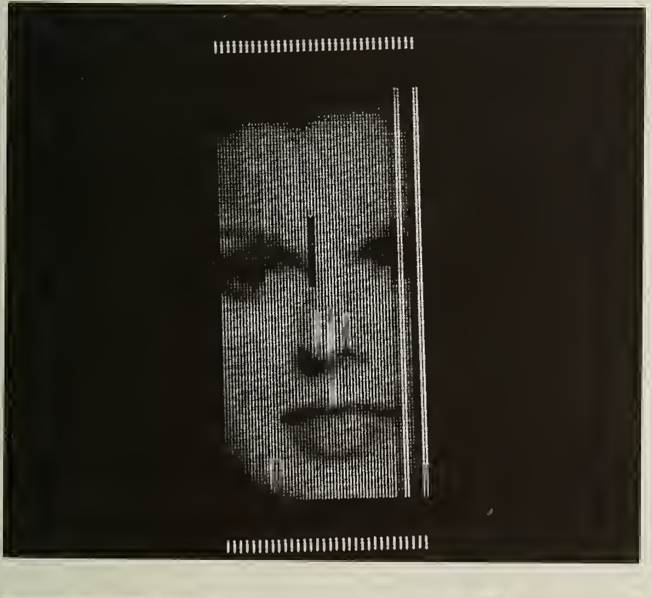
Seven hospitals and clinics are now working with the team, and as the program develops, more will be able to be accommodated. Hopefully Chato and the other team members will prove, not unlike the pint-sized variety, to be important new blood in the health care delivery system. ●

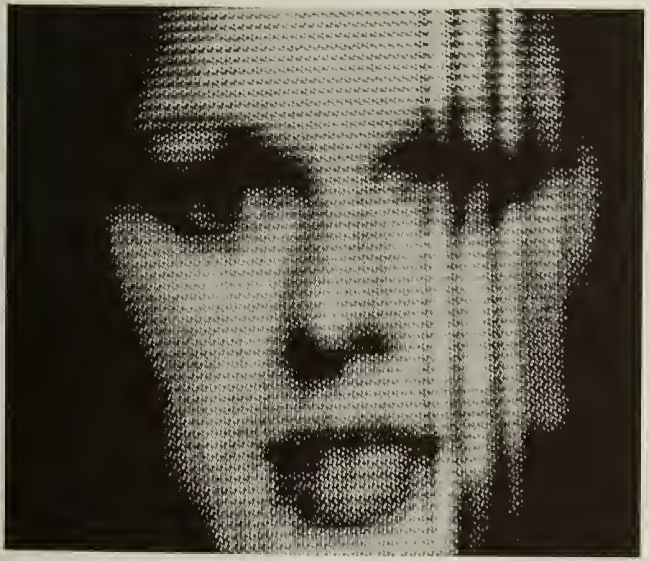
THINK THIN

There have probably been a lot of hang-ups connected with television, but one of them has never been where to hang the television up. However, UIUC engineers have been working on this problem. Sometime in the future, your TV may be hanging on the wall, next to the Van Gogh and taking up about as much space.

This is not possible now, of course, because of the weight and bulk of television sets. But most of the bulk is not wires and circuits — it is the big, cumbersome picture tube. The electronics involved in putting the images on the tube take up relatively little space. Kunio Ando, visiting researcher to the University of Illinois at Urbana-Champaign from Hitachi Ltd., Japan, has been working with Professor Roger L. Johnson, UIUC Coordinated Science Laboratory, to explore possibilities for a television that can use as its screen a plasma display panel less than an inch thick. These are the same panels used in the PLATO system invented at the University.

The major problem in making the switch is that the operation of the display panel is different from the workings of a conventional television set. A picture on a TV screen lasts only as long as there are continuous transmissions from the television station. If the transmissions stop or if the set is turned off, the images disappear. The plasma display panel, which is commonly used with computers, has a memory, and the computer need not transmit an image continuously for it to remain on the panel. Another difference is that television can broadcast light on a continuum; that is, not only bright and dark but at an infinite number of gray levels in between, much in the same way a dimmer switch operates on an electric light. This is called the "gray scale." A display panel does not exhibit gray scale in its conventional mode of operation. It is made up of many tiny light sources which are either on or off; the computer causes the image to be formed by directing which light sources should go on.





The lower photo is of an image on a television screen; the upper photo is the same image as displayed on a plasma display panel in the Coordinated Science Laboratory of the University of Illinois at Urbana-Champaign. Researchers are working on the possibility of making the panels capable of producing clear images with good contrast, so that the panels can be used as screens in future wall-hanging televisions.

For purposes of operating as a television screen, the memory properties of a plasma display panel are not used directly, since television transmissions are continuous anyway. The lack of a gray scale, however, makes it impossible for images to appear on the panel with anything approaching the realism available from a television screen. This is the major problem area, and the one on which Ando and Johnson have concentrated their research.

After preliminary investigation they determined that if a plasma display panel had the ability to produce a gray scale of sixty-four levels of brightness, the distinctions would be small enough that the human eye could not detect the difference between that and the infinite continuum available from a television screen. They then began building the electronic system to accomplish this. The experimental system is now completed, and operates as a kind of optical illusion. Rather than having the brightness controlled by the number of electrons beamed at the tube, as in a regular television set, it is regulated by how long the tiny light sources stay on. The ones lit the least amount of time appear the dimmest; the ones lit the longest are the brightest.

In their laboratory, a small plasma display panel and the electronics required to operate it sit next to a television set which is always on. Between them is the compact circuitry that the researchers designed. This circuitry is connected to both the receiving equipment of the television and the electronic system of the panel. The researchers have set it up so that a small one-inch by two-inch square from the center of the picture on the TV screen can also be viewed on the plasma display panel. Although it is so far just a tiny patch, the picture is quite clear and has good contrast. The researchers feel that a major obstacle has been overcome in the development of the plasma display panel television.

There are still a number of things that must be done before the method will be truly feasible. It must be made capable of handling color broadcasts, and also needs to be reliable, economical, and longlasting in order to be marketable. But given these developments, the new television concept should have everybody screening with joy. ●

LEAD ASTRAY

Heavy metal makes for interesting music and economical gasoline, but its effect on plant and animal systems may be a little too far-reaching for comfort. The National Science Foundation has awarded a grant of $509,700 to the University of Illinois at Urbana-Champaign to continue an interdisciplinary study of environmental pollution by lead and other metals. The money is for twelve months of research in the third phase of study by the Metals Task Force, in which civil engineers and others in the UIUC Institute of Environmental Studies will be working together with the University's forestry department.

The institute, directed by Professor Ben B. Ewing, Department of Civil Engineering, began the study in 1970. Its purpose is to provide decision makers and the public with information to help solve specific problems. Lead in gasoline, for example, assists fuel economy and energy conservation, but causes some problems with environment, health, and crops.

The money is also being used to train students in environmental sciences — perhaps to be lead-ers in their field. ●

PEOPLE AND PLACES

The Walter L. Huber Civil Engineering Research Prize has been awarded to Professor **Alfred J. Hendron, Jr.**, UIUC Department of Civil Engineering, by the American Society of Civil Engineers. He was one of five engineers in the U.S. and Canada to receive the award. Hendron was cited for his research on static and dynamic stresses around underground openings and the slope stability of jointed rock masses. ●

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inside outlook:

ENERGY STORAGE IN MOLTEN SALT
COMPUTER-BASED MECHANICAL TESTING SYSTEM
UPCOMING PUBLIC WATER SUPPLY ENGINEERS' CONFERENCE
HYDROGEN-OPERATED REFRIGERATION UNIT

JUST ADD SALT

To half a power plant-full of leftover generating capacity, add a large quantity of salt. The result will be reduction of the necessary generating capacity and more efficient operation. The plan, cooked up by Professor Robert W. Bohl, UIUC Department of Metallurgy and Mining Engineering, and Professor Marvin E. Wyman, director of the Nuclear Engineering Program, uses salt to store energy during low demand periods in order to meet consumers' needs at peak energy-using times.

Utility companies are required to be able to put out enough energy to meet the highest demand they would have at any time. The demand for electrical energy may double during the course of one day, and certain summer days — hot, humid August afternoons, perhaps, when all the offices and homes have air conditioners running in addition to their normal electrical demand — may make even greater demands on the system. But the generators must be powerful enough to produce this energy, even though a great deal of their capacity will go unused most of the time. Some companies have been able to employ less powerful generators by having on hand "peak units," which burn gas or oil to produce the extra energy needed during peak times. But since the price of fuel has risen, this method is not economical; storing energy has become an even more attractive proposition.

The idea of storing energy is not new; anyone who has considered the use of solar energy, for example, has wondered how he is going to save some up for a rainy day. But so far the methods have not been employed on a large scale, because they involved complicated structure and prohibitive expense. Salt, however, is cheap; incorporating it as an energy storage medium into an already existing generating system would not be costly.

A basic requirement for the production of electricity is steam. Steam is used to spin a turbine and the turbine is connected to a generator of electricity. When the demand is low, less steam is used and the generator works at less than capacity. Decreasing the capacity of the generator and allowing it to run at that level most of the time would be a more efficient way of obtaining the same amount of electricity; this is where the salt comes in.

According to Bohl and Wyman's plan, the steam would be produced at a constant rate. When all of it was not needed, the surplus steam would be drawn off and piped through a vat of salt (one design they are examining is an underground concrete structure 300 by 300 by 50 feet deep, capable of holding 500 million pounds of salt). The heat transferred from the steam through the pipe melts the salt, and the heat is thus stored. When demand for electricity is high, and extra steam is needed to spin the turbine, another pipeline carries water through the vat of molten salt. The heat is absorbed from the salt, solidifying it again, and turning the water into steam which is piped into the turbine.

Salt is useful for energy storage not only because it is cheap, but because it absorbs a lot of energy in order to melt, and has an appropriate melting point (between 400° and 600°F). The salt will retain its heat for a surprisingly long time. The process doesn't use up or contaminate the salt, either; it simply melts it and solidifies it.

The main concern of the researchers with the system is that the energy is able to be absorbed by and absorbed from the salt rapidly in a given amount of time. The rate at which energy is transferred determines the level of power that can be reclaimed from the salt. This power must be at a high enough level to make the system a practical one. Bohl and Wyman are currently investigating this aspect of the system.

One area in which this energy storage plan will be particularly helpful is in nuclear power plants. For them a constant rate of energy production is more important to smooth operation and efficiency than for conventional plants.

With energy conservation so often appearing a dry subject peppered with cold, hard facts, it is good to see a little salt spicing up the application of pertinent, practical research. ●

REDUCING THE CIRCLE OF CONFUSION

From time to time, we like to remind our readers that there are two Colleges of Engineering at the University of Illinois; both the Urbana-Champaign campus and the Chicago Circle campus have separate colleges each of which reports to the chancellor of its respective campus.

The College of Engineering at the University of Illinois at Chicago Circle (UICC) is organized into four departments (Energy, Information, Materials, and Systems) and the Bioengineering Program. The College of Engineering at the University of Illinois at Urbana-Champaign (UIUC) is organized into eleven departments (Aeronautical and Astronautical, Agricultural, Ceramic, Chemical, Civil, Electrical, General, Mechanical and Industrial, Metallurgy and Mining, Physics, and Theoretical and Applied Mechanics), two interdisciplinary labs (Coordinated Science Laboratory and Materials Research Laboratory), and the Nuclear Engineering Program.

A recent article (*Outlook,* January 1975) stated that a bioengineering grant received by the University of Illinois at Urbana-Champaign was the first of its type received. This led to some misunderstanding, since the College of Engineering at Chicago Circle has had an active, vigorous program of bioengineering for the past eight years and has previously received a number of similar grants. We regret the confusion and will attempt to avoid such misunderstandings in the future. ●

BREAKTHROUGH

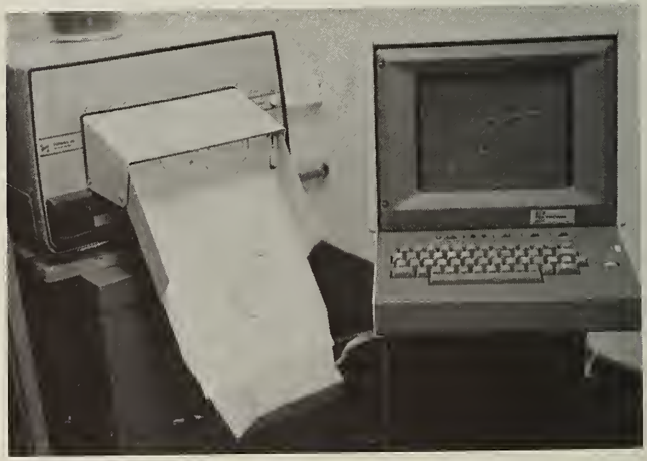
Everything eventually breaks, falls apart, or wears out. For each material and situation, failure occurs for different reasons and in different ways. Engineers study the failure of materials by conducting tests to determine their mechanical resistance.

Throughout the history of mechanical testing, various types of machines and methods have been used. They tested static strength (how much load can be borne), fatigue (how much a material can be repeatedly loaded before snapping), creep (time-dependent deformation under load), and brittle fracture (how low temperatures combined with rapid loading can affect the cracking and breaking of materials). For these tests, a variety of machines have been used to push, pull, bend, and shake test specimens. The apparatus originally used ranged from table-top size to huge devices for which special rooms had to be built. Over the years the machinery became less cumbersome and more sophisticated, but testing processes were still time-consuming and awkward. Now a new materials testing system has been developed, and is still being improved, which makes even complex tests of materials less difficult to administer.

Unlike previous testing machines, this new system is computer-based. A computer controls the testing apparatus so that virtually any type of materials test can be conducted. Engineers at the University of Illinois at Urbana-Champaign — in cooperation with MTS Systems Corporation, which developed the system — are examining its new uses, assessing its research potential, and making suggestions for applications and improvements.

Professor JoDean Morrow and graduate researcher Kelly Donaldson, UIUC Department of Theoretical and Applied Mechanics, have found one of the major advantages of the system to be its flexibility and ease of programming. In complex mechanical tests involving programmed changes in the force on the test specimen, the material's response can be visually displayed and recorded on magnetic tape cassettes. Once a test is coded onto a tape, it can be run over again for purposes of comparing the behavior of different materials or verifying results on the same material.

The system not only streamlines the testing process, but is easy for the user to operate. A conversational program-



The new computer-based mechanical testing system, now being examined by engineers at the University of Illinois at Urbana-Champaign, has the special feature of being able to visually display a material's response to a particular type of test, both on a screen (as shown at right) and on paper (shown at left). The system can also record the response on magnetic tape cassettes.

ming language is used; eventually tapes will be available for the system to instruct new users on how to operate it and solve materials testing problems.

Soon Morrow and Donaldson expect the system will be able not only to conduct tests, but interpret the results and put them in report form. Some people get all the breaks. ●

THEME WITH VARIATIONS

"2001: An Engineering Odyssey" is happening in 1975 — on March 14 and 15, when the UIUC College of Engineering celebrates with the public its annual Engineering Open House.

This year's theme emphasizes the many and varied areas affected by engineering. The open house provides an excellent opportunity for the public, particularly those interested in engineering careers, to explore these areas and the part engineering plays in them.

Every year visitors from Illinois and surrounding states attend Engineering Open House to see the facilities and activities of the UIUC College of Engineering. The two-day event helps to promote meaningful relationships between the academic world of engineering and the world of humanity which it serves. ●

SYSTEMS ANALYSIS

The seventeenth annual Public Water Supply Engineers Conference (formerly the Water Quality Conference) will be held in Champaign, Illinois, April 29 and 30. Entitled "Water Distribution Systems," it is jointly sponsored by the UIUC Department of Civil Engineering, the Illinois section of the American Water Works Association, the Illinois Environmental Protection Agency, and the American Society of Civil Engineers.

The conference is for engineers, designers, planners, regulators, and water works managers and operators who seek an understanding of the factors important in making technical decisions related to distribution systems. Proceedings will be published and available from the Engineering Publications Office, 112 Engineering Hall. Further information about the conference is available from Professor Michael J. Semmens, 3207 Civil Engineering Building, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

HYDROGEN CONDITIONING

When air conditioning people get left out in the cold by natural gas companies, will they be able to keep their cool? That will depend upon whether something is prepared to fill the gap left by natural gas. If plans currently under consideration go into effect, hydrogen will be taking the place of methane in the refrigeration process in air conditioners.

In the not-too-distant future, usage of natural gas may be stringently limited. Residential heating and cooling will be among the hardest hit. If hydrogen replaces methane, then there will be a need to operate air conditioners with hydrogen also. One UIUC engineer is trying to develop a system that would be comparable in operation to one of the proposed hydrogen-producing methods.

One method being studied for hydrogen production is called thermochemical, and at the University of Illinois at Urbana-Champaign it is also being applied to refrigeration. The thermochemical method offers an alternative to hydrogen production by electrolysis (the decomposition of water into hydrogen and oxygen with an electric current). Hydrogen could also be burned and the heat used to operate an absorption refrigeration unit; but Professor W. F. Stoecker, UIUC Department of Mechanical and Industrial Engineering, has been working for about one year on a thermochemical cycle.

In any refrigeration system heat, oddly enough, plays an important role. The currently used absorption method is adaptable to the use of hydrogen instead of methane. In this process a solution of refrigerant and absorbent, such as ammonia and water, is heated in a boiler by an external source (the burning hydrogen and air mixture). Since the refrigerant has a lower boiling point than the absorbent, it is driven off as a vapor, leaving the absorbent behind. At the high pressure within this enclosed chamber, the refrigerant finally condenses and passes through an expansion valve. As it expands in an evaporator, it absorbs heat from air being blown into the room. The absorbent which remains is air-cooled and then recombined with the refrigerant vapor coming from the evaporator. The solution is sent through a pump to increase the pressure, reheated, and the process begins anew. Through the magic of physics, heat is made to produce cold.

The thermochemical method Stoecker is working on would also use heat. However, it would not be produced by combustion but by a different chemical reaction. Actually two types of reactions are involved. The first one occurs at low temperature, causing heat to be absorbed from the air that is to be cooled. The heat is then carried into another chamber where a reaction occurs that expels the heat. Other products of the second reaction are carried back to the first chamber to complete the cycle.

In beginning his research, Stoecker considered all the possible reactions having hydrogen as a reactant and water as a product. He chose from among them those that might be possible cycles in a thermochemical refrigeration system. Further investigation is needed to determine their feasibility. Reactions involving silver, for example, will probably prove to be too expensive to consider. Other reactions, though they appear to be theoretically possible, may not work in an actual system. Stoecker hopes to use models in subsequent stages of his study, in order to test his theories.

It has not yet been determined whether the proposed thermochemical method is significantly better than the absorption method, but as an alternate possibility it may prove important when hydrogen-operated systems are finally designed. Certainly it makes a hydrogen economy one of the more realistic pipe dreams of energy conservationists. ●

PEOPLE AND PLACES

Professors **D. L. Day** and **D. G. Jedele**, UIUC Department of Agricultural Engineering, received certificates from the Livestock Environmental Sciences Committee for their work in environmental control for feedlots.

For his contributions to the theory and development of the log-periodic antenna, Professor **Paul E. Mayes**, UIUC Department of Electrical Engineering, has been elected a fellow of the Institute of Electrical and Electronics Engineers.

Professor **Ven Te Chow**, UIUC Department of Civil Engineering, received the 1975 Professional Achievement Award from the Chinese Engineers and Scientists Association of Southern California for his distinguished contribution to teaching, research, and public service in the field of hydraulic engineering. ●

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COLLEGE OF ENGINEERING
VOL. 16, NO. 8, MARCH 1975

inside outlook:

STUDY OF CONCRETE BUILDING CODES
UIUC'S COAL GASIFICATION PROJECT
SOYBEAN PROCESSING FOR FOOD USE
1975 INTERNATIONAL SYMPOSIUM IN ELECTRONICS

DECODING AND ENCODING

Buildings that crash unexpectedly to the ground usually get write-ups in the newspaper. But it is not news if a building simply remains standing through years of supporting people, furniture, and machinery. Fortunately, most buildings are of the un-newsworthy variety; they were built according to rigid codes which, being successful, have not been subjected to much critical scrutiny. But, as the cost of materials goes up, the question arises whether the codes are too rigid, resulting in building costs that are too high.

UIUC graduate researcher J. B. Mkandawire, under the direction of Professors N. Khachaturian and R. A. Eubanks, Department of Civil Engineering, has been examining an aspect of the code for tall concrete structures. The codes for building with concrete were in many cases carried over from those used for steel structures; some of them may have been carried over uncritically. Mkandawire is not concerned with whether concrete buildings built under these codes are safe enough, since that is not a problem, but whether the codes are as accurate and economical for use with reinforced concrete as they are for steel.

Reinforced concrete is not homogeneous; it has steel in it, in the form of bars, welded wire fabric, or tiny "needles." It also cracks and exhibits creep (gradual deformation under load), unlike steel alone. But it is an economic material for building. If conventional design procedures for concrete buildings could be modified to result in structures which are still safe but less restrictive, concrete would become even more desirable as a construction material.

A major concern in Mkandawire's work is the current design of the long reinforced concrete columns used in tall buildings. He is evaluating the behavior of these columns under the combined factors of vertical load (the weight they must hold up) and side load (effects of wind, earthquakes, etc.). These are critical considerations to a designer when he is planning the type of structure he will build in a particular locality. Safety in columns is more crucial than in horizontal beams, since the failure of a beam usually damages only one floor, while the failure of a column results in major destruction to every floor of the building. But no failure at all is desirable to the designer — or to the people in the building.

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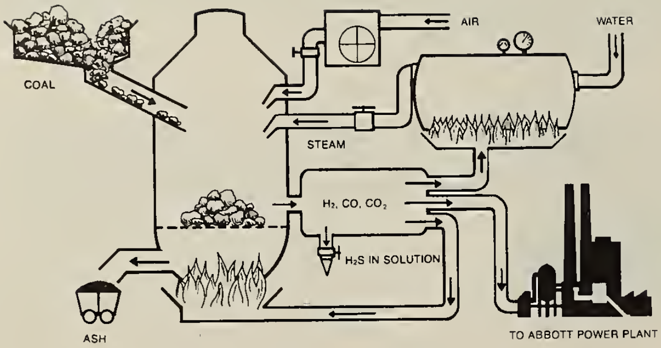
As the reseacher's work progresses, he has found that in many cases the codes do require structures to be more than adequately safe, and these can be changed to result in buildings which are satisfactorily safe, but cost less. In this study he is using hand computations and combining them with computer calculations to work out formulas that building designers will be able to use with a slide rule.

Mkandawire has been working on his project for about a year, and plans to complete it soon. After that, he hopes its application to building and design practices will last at least as long as the buildings that never make the news. ●

LEFT OUT IN THE COAL

Next to turning a sow's ear into a silk purse, perhaps the most difficult task facing this country is the location of an economical, clean, nonpolluting source of energy. A group of UIUC engineers think that they have a solution which appears to be almost as marvelous, and certainly more practical, than the proverbial transformation.

The state of Illinois has within its boundaries one-fifth of the nation's estimated total supply for bituminous coal, nearly 148,000,000,000 tons, more than West Virginia, Kentucky, or Pennsylvania. Coal underlies two-thirds of the state. But Illinois ranked only fourth in production in 1971, producing only half as much as West Virginia or Kentucky and less than 80 percent as much as Penn-



Engineers at the University of Illinois at Urbana-Champaign are developing the coal gasification process shown here to remove sulfur from Illinois coal by combining air, coal, and steam to produce a medium heat-capacity gas, free of sulfur. One proposal under review would provide the gas to the UIUC's Abbott Power Plant to burn in place of number two fuel oil.

sylvania. The reason is that nearly all Illinois coal is high in sulfur content. The distinction between high- and low-sulfur coal is vital since 1975 sulfur dioxide control regulations are so severe that they will effectively prohibit the burning of Illinois coal.

Engineers at the University of Illinois at Urbana-Champaign under the direction of S. L. Soo, B. T. Chao, J. C. Chato, and J. J. Stukel, UIUC Department of Mechanical and Industrial Engineering, have developed a process which has the potential of turning high-sulfur Illinois coal into a clean, medium-energy gas. Desulfurization is usually thought of in terms of stack gas scrubbing (removing sulfur dioxide from the exhaust gas after the coal has been burned or coal prewashing (removing the sulfur before the coal is burned). But it can also be removed during gasification. The coal is converted to a gas which is pipelined to the customer free of problem-causing sulfur.

The gasification process converts a mixture of steam and coal to hydrogen, carbon monoxide, carbon dioxide, hydrogen sulfide, and other constituents. Steam for the process is produced by burning part of the gas generated. In the process, the sulfur in the coal is converted to hydrogen sulfide which is readily removable. The coal used can be "run of the mine" which requires no sizing, grading, or preprocessing. When burned in a power plant, the gas causes no significant pollution and permits more efficient operation at lower stack gas temperatures.

Numerous schemes have been proposed (and some are in operation) for the gasification of coal. But the UIUC proposal differs in a number of important respects. This design is directed toward small municipal power plants, industrial-sized power plants, and other medium-sized users with an operating capacity of 700 to 800 tons of coal per day. Giant gasification plants of 10,000 tons or more are currently under design or construction using other principles of gasification.

The produced gas is a medium-Btu gas of approximately 340 Btu/cu ft (British thermal units per cubic foot). High-Btu gasses (1,000 Btu/cu ft) require additional processing, such as methanation. Low-Btu gasses (150 Btu/cu ft) require a great deal of auxiliary equipment. The UIUC process uses steam instead of oxygen, does not require preprocessing of the coal, and can accommodate coal of varying quality.

Water requirements for both cooling and consumption, which can be quite prodigious for some gasification schemes, are relatively modest. A ten-acre spray pond will serve for cooling and the amount of water consumed is less than 120 gallons per minute (half an acre-foot per day).

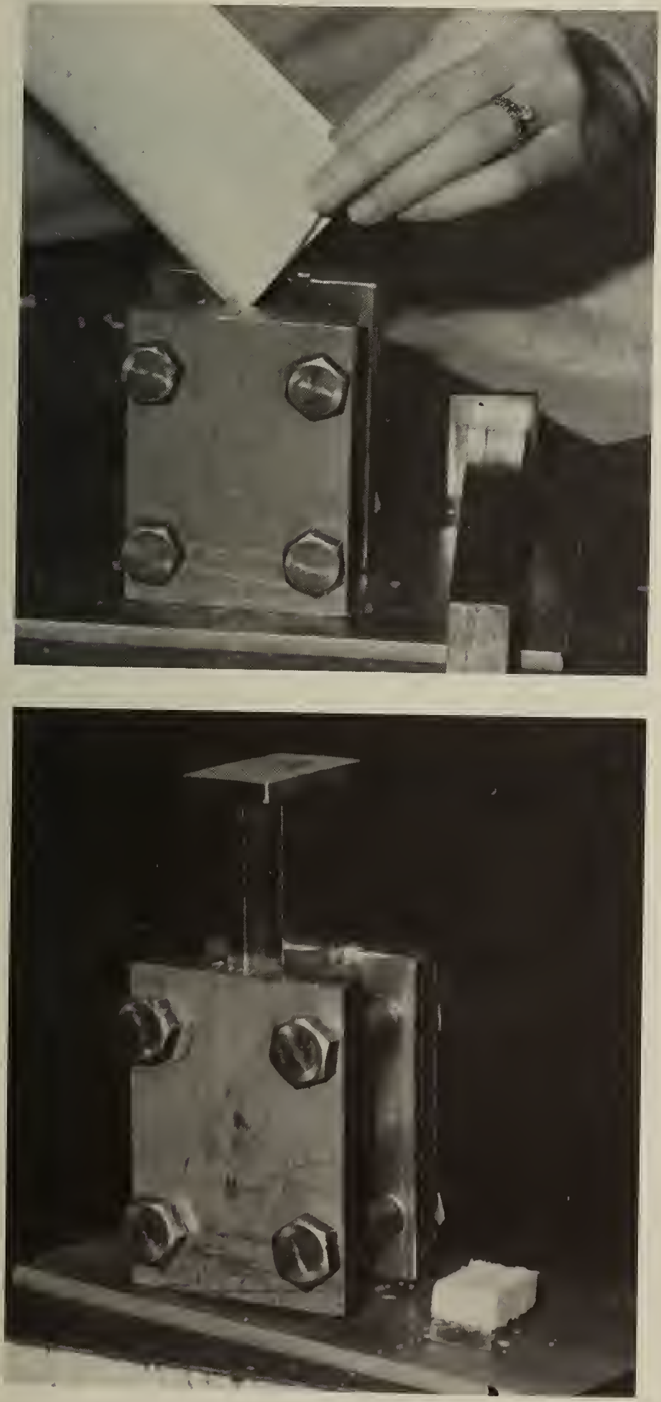
As a demonstration of the process, UIUC engineers have proposed a gasification plant to be constructed on the Urbana-Champaign campus to provide gas to the UIUC Abbott Power Plant which currently burns oil. Since oil and gas burners are readily interchangeable, the power plant can continue operation unabated with either gas or oil as circumstances dictate. Since the power plant has been subjected to the same skyrocketing fuel costs as other consumers (the price of number two fuel oil is expected to have tripled by 1976 over its 1972 prices), it welcomes the proposed gasification facility which has the potential to reduce costs without the necessity and added expense of yet unproven stack gas scrubbers in order to burn cheaper, more plentiful Illinois coal.

A former president of the University of Illinois, Andrew Sloan Draper, once said, "The wealth of Illinois is in her soil and her strength lies in its intelligent development." Although he had agriculture in mind, he couldn't have been more correct about coal. At $20 per ton, the estimated recoverable coal reserves of Illinois are valued at $1.5 trillion. UIUC engineers hope their gasification proposal will contribute to the intelligent development of this vital Illinois resource. ●

TO PRACTICE WHAT THEY TEACH

The Department of Chemical Engineering at the University of Illinois at Urbana-Champaign has received a $20,000 young faculty grant from E. I. du Pont de Nemours & Company, Wilmington, Delaware. UIUC was one of sixteen major universities to receive the grant. It will be awarded to a person designated by UIUC who has received a doctorate within the past five years, to encourage a research career.

Two other grants of $6,000 each to the UIUC Departments of Chemical Engineering and Mechanical and Industrial Engineering were awarded by du Pont to support teaching and research. ●



A machine usually used for the mechanical testing of engineering materials is coming in handy in food experimentation at the University of Illinois at Urbana-Champaign. One project uses the machine to make banana-soybean bars. In the top photo banana-soybean flakes are being poured into a mold. In the bottom photo, the process has been completed: the flakes have been pressed by the machine into a solid, rectangular bar. Different amounts of pressure are being tried to determine which results in the most edible texture.

HAS-BEAN

No matter how well grandma cooked, the contemporary chef may be willing to try a few new utensils and methods she never used. But reorienting taste buds to new flavors and textures is harder to do. One of the goals of agricultural engineers is to help make foods palatable and healthy as well as plentiful. Soybeans have been the target of a lot of their research, much of it dealing with making the beans good to eat.

Although a favorite food of livestock, soybeans have not caught on with the American eating public because of a taste and smell associated with the beans which Americans find objectionable. This taste and smell, however, were found to have been caused by the reaction of an enzyme in damaged soybeans when they come in contact with water. Protecting the beans from damage is one way to make them a more acceptable food. Professor E. D. Rodda, UIUC Department of Agricultural Engineering, learned that another way of making soybeans taste good is by combining them in unorthodox ways with machinery in the laboratory.

The first good-tasting bean recipe Rodda developed this way actually came as a surprise. He was conducting a laboratory session on grain drying and needed to reduce quickly the moisture content in some beans he was using. He looked around the laboratory and decided to try fast-drying them in a microwave oven. The rapid heating made the beans "pop." Rodda found that, with the addition of a little butter and salt, the popped beans made a delicious, healthy snack. Beans with a moisture content of about 20 to 22 percent are best for this. Adding a quarter cup of water to a pound of dry soybeans gives them the proper moisture content. They are refrigerated overnight in a tight container, so that the water can soak through the beans. Then five minutes in the microwave oven pops them.

Rodda is also working with the Department of Food Science on another soybean food product. He has been putting banana-soybean flakes in a mold and applying different amounts of pressure with a mechanical testing machine to create a banana-soybean bar. Two varieties of soybeans are being used in the flakes. Rodda is comparing them for flavor, and is determining what combination of pressure and moisture content allows the flakes in the bar to hold together well and still be easy to eat.

With the growing national concern for nutrition combined with economy, agricultural engineers are able to aid directly in the reorganization of food habits and priorities. This doesn't exclude exalting the humbled soybean; nor does it rule out popping and pressing in the lab. ●

SWITCHED-ON SYMPOSIUM

Electronics scientists from the United States and other countries will meet June 2-5 at the University of Illinois at Urbana-Champaign to discuss current research and developments in radio antennas and radio wave propagation. The meeting will be the 1975 International Symposium of the Antenna Propagation Society (part of the Institute of Electrical and Electronics Engineers) and the U.S. National Committee of the International Scientific Radio Union (known as URSI for its name in French).

Discussions will deal with such topics as antenna design and special applications, the ionosphere and the magnetosphere, and the biological effects and medical application of microwaves.

Details and schedules can be obtained from Professor G. A. Deschamps, UIUC Department of Electrical Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

Professor **Loren E. Bode,** UIUC Department of Agricultural Engineering, has been elected national president for 1975 of Alpha Epsilon, agricultural engineering honor society.

Professor **Daniel F. Hang,** UIUC Department of Electrical Engineering and the Nuclear Engineering Program, was named chairman of an Illinois Society of Professional Engineers committee working with the Illinois Energy Resources Commission. The committee will provide consulting services for the commission whose mission is to evaluate proposals for activities in the state's $70 million energy program.

Professor **Martha E. Williams,** UIUC Coordinated Science Laboratory and director of the Information Retrieval Research Laboratory, has been named editor of the *Annual Review of Information Science and Technology* (ARIST), a publication of the American Society for Information Science (ASIS). ARIST provides to researchers evaluative reviews of the year's literature in information science and technology.

Professor **Herman Krier,** UIUC Department of Aeronautical and Astronautical Engineering, has been selected to serve on the Propellants and Combustion Technical Committee of the American Institute of Aeronautics and Astronautics. ●

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COLLEGE OF ENGINEERING
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inside outlook:

CONTROLLING FUGITIVE DUST AT CONSTRUCTION SITES
STUDY OF LUBRICATION PROBLEMS OF HEAVY EQUIPMENT
UIUC ENGINEERING ALUMNI RECEIVE AWARDS
SURVEY OF UIUC ENERGY-RELATED RESEARCH AVAILABLE
USING SOLAR HEAT TO DRY GRAIN

DUSTING OFF

It seems ironic that the Lone Ranger always completed each of his good deeds by galloping off dramatically in a cloud of air-polluting dust. But with or without good deeds, the "fugitive dust" phenomenon continues — when a car drives down a dirt road, or when a farmer plows a field.

One activity plagued with fugitive dust as a by-product is construction. Professor J. J. Stukel, UIUC Departments of Civil Engineering and Mechanical and Industrial Engineering, has been examining various construction practices to determine what levels of pollution can be expected from construction activities.

When large equipment moves around a construction area, it inevitably kicks up dust; how much dust depends upon how heavy the vehicle is, how fast it is moving, how dry the road bed is, and what type of road it is. Stukel's research is aimed at predicting how much dust there will be under various conditions and how this fugitive dust can be controlled.

To find out what they wanted to know, Stukel and the researchers working with him chose dirt roads of various compositions and ran trucks of several loads at different speeds over them. In each case they studied the silt percentage in the soil (silt is a major component of dust), and the percentage of moisture in the dirt. The speed and direction of the wind were also recorded. To make sure that they were accurately measuring the silt concentration caused by the trucks, they made an upwind measurement of the silt concentration in the air and subtracted that from the downwind measurements. In each place where they conducted their experiment, it had not rained for at least two days, assuring that the soil was relatively dry.

From the data Stukel developed a model relating the dust emissions around the vehicle to the measured concentrations at various points downwind. Since the concentrations become lower as the dust is dispersed further by the wind, this model allowed him to predict how far the dust would travel. The next step in the research will be working out a method of controlling the dust economically.

Dust in the air is troublesome not only by itself but because it can act as a medium for carrying other pollutants. Certainly what goes up must come down, but it is the wanderlust of dust that blows away a simple solution to the problem. ●

SHIFTING GEARS

The pros and cons of being a specialist are well known to people in many fields. Along with the advantage of having that singular knowledge necessary to deal with special situations comes the disadvantage of a set of frequently unusual problems. Heavy equipment manufacturers are often in this position. The machinery they manufacture for particular needs is usually expensive to make and in limited demand; so they need to deal with any problems as efficiently and effectively as possible, with a minimum of expensive design changes.

Researchers at the University of Illinois at Urbana-Champaign are working with equipment manufacturers in one of these areas: creating trouble-free transmissions for large types of heavy machinery that are not substantially different in design from those used in smaller types of heavy machines.

The transmissions in heavy equipment are not the same as those in automobiles. The oil used to lubricate the gears is circulated through the entire engine system in an automobile; a cheaper "splash" lubrication system is used in heavy equipment. Under this system, the gear box (transmission) is filled to a certain level with oil, and it is the movement of the gears themselves, rather than a separate pump, that circulates the oil around the gears. While this system works well in most heavy equipment, it has been found to create occasional overheating problems in especially large machinery. The splash lubrication system is a closed system. Unlike an automobile, where the heat generated has a chance to dissipate as the oil is circulated, the heat built up in a splash lubrication system can only be dispelled by heat transfer from the inside to the outside of the box. Why this is a problem only in large types of heavy machinery is being investigated by C. S. Larson, assistant dean and associate professor of mechanical engineering, along with his graduate researchers and several engineers from the heavy equipment industry.

In studying what affects the temperatures inside the gear box, particularly that of the oil, the investigators first identified the most important variables in dissipating the heat. They turned out to be the speed of the gears, the amount of oil, and the space between the gears and the side of the box. Then they tried to manipulate these without introducing any new variables. They are conducting their study using heavy-equipment transmissions in the laboratory. A transmission is mounted and driven by a motor; as it is run at different speeds, with different amounts of oil, and with different clearance between the gears and the box, they are observing the temperature distribution by measuring the temperature of the oil at several places inside the gear box.

The researchers have found that even small changes in clearance or depth of oil can result in big changes in operation and temperature distribution. The type of oil used is a very important factor. Thick oil needs more power to circulate; this generates more heat, but thick oil lubricates better than thin oil. The researchers want to discover the most appropriate oil mix for transmissions in large equipment.

Larson and the investigators working with him hope to develop a set of guidelines for design that will lead to something more sophisticated than a mere splash in the pan. ●

LIFETIME SERVICE

Seven alumni of the UIUC College of Engineering were honored recently at the University of Illinois at Urbana-Champaign with Alumni Honor Awards for Distinguished Service in Engineering. The persons "have distinguished themselves by outstanding leadership in planning and direction of engineering work, by fostering professional development of young engineers, or by their contributions to knowledge in the field of engineering."

Cited for distinguished service in their respective fields were **George R. Carruthers**, research astrophysicist, U.S. Naval Research Laboratory, Washington, D.C.; **Frank S. Flick**, president, Flick-Reedy Corporation, Bensenville, Illinois; **Robert M. Hainsfurther**, retired vice president and general manager, Glass Division, PPG Industries Incorporated, Pittsburgh, Pennsylvania; **Barbara Crawford Johnson**, manager, Mission Requirements and Integration, Space Shuttle Programs, Space Division, Rockwell International, Downey, California; **Seichi Konzo**, professor emeritus and associate head, UIUC Department of Mechanical and Industrial Engineering; **Frank E. Richart Jr.**, professor of civil engineering, University of Michigan; and **William C. Wiley**, vice president and chief technical officer, Leeds and Northrup Company, North Wales, Pennsylvania.

In crediting the field of engineering, these engineers have also been a credit to the UIUC College of Engineering, and serve as an example and an inspiration to its researchers, both present and future. ●

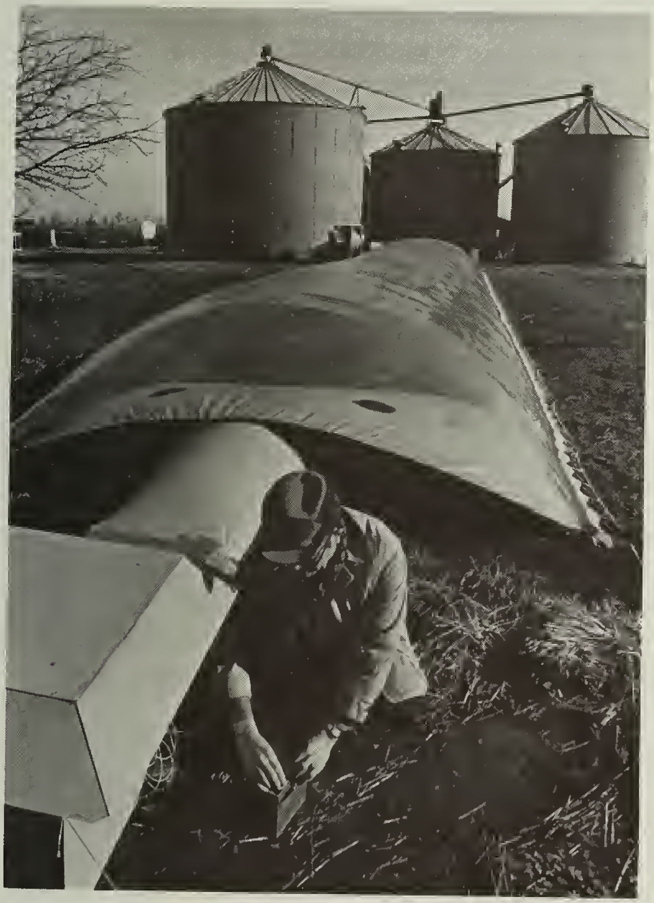
KW VS. $

The first step in solving a problem is figuring out what it is. The next step is finding out if someone else already has a solution or is working on one. Faced with the prospect of more expensive or greatly reduced energy sources, the nation is beginning to take stock of the situation and to assess what has already been done that applies to dealing with the shortage.

As its contribution to this national inventory taking, the University of Illinois at Urbana-Champaign has done some soul-searching of its own which has been published as *A Survey of Energy-related Research at the University of Illinois at Urbana-Champaign*. This 286-page document presents in looseleaf form nearly 200 research projects cutting across a number of colleges and dealing in all areas of energy.

The projects described span from the operation of as yet unbuilt fusion reactors to the reduction of fuel consumption in agricultural production through better field practices. They are as immediate and practical as techniques to predict the location and character of coal deposits and as advanced as means of producing cell-free photosynthetic reactors to convert sunlight into a usable plant food product more efficiently.

Copies of *Energy-related Research* are available from the Engineering Publications Office, 112 Engineering Hall, Urbana, Illinois 61801, at a cost of $10.00 each. Remittance should accompany the order. ●



Professor G. C. Shove, UIUC Department of Agricultural Engineering, prepares a plastic-bag-like solar collector for use in drying corn. Boxed in the foreground is the fan, which blows air into the bag where trapped solar radiation heats it. The collector is connected to the storage bin on the left in the background, and the heated air from the bag is forced by another fan up through the grain.

SUNDRIES

Depending upon one's point of view, the most important contributions the sun makes in the months ahead may be warm weather and a suntan. To those in energy circles, however, light and heat from the sun have proven to be valuable inside as well as outside, and solar heat in particular has been investigated for practical applications.

Even before obtaining fuel became a major problem, agricultural engineers did some experimental work with farmers on the use of solar heat to dry crops. Crops are allowed to dry to some extent in the field to prevent damage during harvesting, but they must be further dried afterwards to prevent spoilage during storage and shipping. Using solar heat in this later drying process did not become economically attractive until fuel prices began to rise. An agricultural engineer at the University of Illinois at Urbana-Champaign is currently testing and improving a number of methods of drying grain, particularly corn, through the use of solar heat.

Most grain drying has been done with high heats — from 20 or 30 degrees above outside temperatures to as high as 160° to 200°F. Although it results in conveniently fast drying, it entails the use of expensive equipment and scarce, high-priced natural gas. A high-temperature dryer costs from $9,000 to $20,000, and to use it a farmer must also buy bins for holding grain, and other related equipment. As a farmer's harvest increases, greater investment in high-temperature drying machinery frequently proves too expensive. At this point he often considers a low-heat drying method, and solar energy provides this simple solution.

Two methods are being tried by Professor Gene C. Shove, UIUC Department of Agricultural Engineering. One uses outer, solar-collecting walls built around storage bins. An enclosed fan is built into the outer wall. As air is pulled by the fan through the space between the bin wall and the solar-collecting wall, it picks up heat from the sun. The fan then forces this heated air up through the grain, drying it to the desired moisture content (about 15 percent for corn.)

A second method uses a long, low inflatable bag made of tough plastic. The bag lies on the ground, and is connected to a fan at one end and the grain storage bin at the other. The top of the bag is black plastic, loosely covered with another piece of translucent plastic. The energy in the sunlight passes through the translucent plastic and is absorbed by the black surface underneath. The black surface reradiates the energy, but at a wavelength that will not pass through the plastic. Instead the energy, in the form of heat, is passed to the air blown into the bag by the fan. By the time the air in the bag reaches the storage bin it is warm enough to dry the grain as it is forced up through the bin. The translucent plastic that covers the black top of the bag makes the collector more efficient, helping to trap the sun's radiation.

Each of the two types of methods has its own advantages. The outer vertical wall is best for October and November, since it is more efficient for collecting heat because of its angle in relation to the low winter sun. But the black-topped bag covered with translucent plastic is more efficient in principle: the clear covering traps escaping heat waves. Such plastic coverings have been tried over the vertical walls, but they have usually been battered and torn off by the wind. Shove is working on the idea of putting up translucent fiberglass coverings around the black solar-collecting walls to improve their efficiency.

The idea of grain drying with solar heat isn't new, but since fuel is now a problem, and at the same time low-temperature drying is increasing in popularity, Shove is devoting serious study to furthering understanding of solar drying by these methods. He believes that, in addition to its application to corn in the Midwest, it will also prove a valuable method for drying soybeans, which cannot be dried by high-temperature methods.

Hopefully in about two years a solar collector will be available from grain drying equipment manufacturers for corn farmers and others to buy at reasonable prices. If nothing else, it should go a long way toward keeping them from being wet behind the ears. ●

PEOPLE AND PLACES

Four outstanding students in the UIUC College of Engineering received special awards recently in the college's eleventh annual Honors Convocation. The Honeywell Award for distinguished performance and leadership went to junior **James L. Barbour**, Department of Chemical Engineering. **Douglas A. Lauffenburger**, senior in chemical engineering, received the Lisle Abbott Rose Memorial Award for technical excellence combined with cultural breadth, depth, and sensitivity. The Harvey H. Jordan Award for scholastic standing and character was presented to **David K. Wells**, graduate student in electrical engineering; and **Louis E. Ogden**, senior in industrial engineering, earned the Elmendorf World Citizenship Award for travel by an engineering student with a strong interest in world affairs.

Also recognized at the Honors Convocation were Professors **Clifton G. Bergeron**, Department of Ceramic Engineering, and **Robert E. Miller**, Department of Theoretical and Applied Mechanics, who received the Everitt Award for Teaching Excellence, established to honor Dean Emeritus William L. Everitt. The Stanley H. Pierce Award, given to the student and faculty member who have done the most to develop empathetic student-faculty cooperation, was presented to **Michael W. Miller**, junior in aeronautical and astronautical engineering, and Professor **Marshall R. Thompson**, Department of Civil Engineering.

Professor **Nathan M. Newmark**, UIUC Department of Civil Engineering and Center for Advanced Study, has been named Corresponding Academician of the Mexican Academy of Engineers.

For his research and testing, Professor **Jo Dean Morrow**, UIUC Department of Theoretical and Applied Mechanics, has been honored by the Society of Automotive Engineers with a Certificate of Appreciation. ●

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COLLEGE OF ENGINEERING
VOL. 16, NO.10, MAY 1975

inside outlook:

UIUC COLLEGE OF ENGINEERING TIME CAPSULE
STUDY OF VERTICAL AXIS WINDMILLS
BIOMECHANICS OF SPERMATOZOON MOTION
UIUC TOPS IN ENGINEERING RESEARCH EXPENDITURES

CAN YOU DIG IT?

Not to be outdone by the knowledge of outer space that will be gained in the next twenty-six years, a number of departments of the UIUC College of Engineering have prepared some inner space to be explored in the year 2001.

The space, three feet long and nineteen inches in diameter, is a cylindrical, stainless steel time capsule, containing items representing significant engineering research conducted at the University of Illinois at Urbana-Champaign. It was sealed and buried near the campus's Engineering Hall as part of the 1975 Engineering Open House, which carried the theme, "2001: An Engineering Odyssey." The burial spot is marked by a four-and-a-half-foot tall monolith.

Some of the items included in the capsule are a ceramic bone implant made by researchers in the Department of Ceramic Engineering; an electronic cow feeding system unit, contributed by UIUC agricultural engineers; four types of light-emitting diodes, three of which were developed by UIUC electrical engineers; an airfoil designed in the Department of Aeronautical and Astronautical Engineering that permits large aircraft to land on short runways and leave with near-vertical take-off; a solar-powered computer which needs no wire connections, contributed by computer science; and a transistor and a piece of wire from a superconducting coil contributed by the UIUC Physics Department, both of which are associated with the two Nobel Prizes of Professor Emeritus John Bardeen, as well as a number of other samples of UIUC engineering research work.

When the time capsule is dug up in the year 2001 it should provide, in addition to a dose of nostalgia, some interesting concrete evidence of how the engineering developments of today have influenced the technology of tomorrow. ●

PUTTING ON AIRS

Unlike Don Quixote, who tried to joust with them, an undergraduate engineer at the University of Illinois at Urbana-Champaign has found it more productive to work with windmills in a calm and scholarly way. There is quite a bit of room for discovery; the study of windmills and their operation declined with the advent of electrical power. But the possible use of windmills as a supplemental energy source has led to renewed interest in this age-old means of harnessing the wind.

The ubiquitous, horizontal-axis windmill which dotted the American plains at the beginning of the century was used primarily to pump water, unlike its popular European counterpart which was used chiefly to power grain mills. But a horizontal-axis windmill which is capable of efficient power output has several disadvantages: the blades are complex to manufacture, and it has to be mounted on a towerlike structure and pointed into the wind to operate. Vertical-axis windmills, invented around 1930, don't have these problems. But they have not yet been extensively studied, so they are not well understood or widely used. Timothy R. Richards, senior in aeronautical and astronautical engineering, hopes to change all that by learning more about them.

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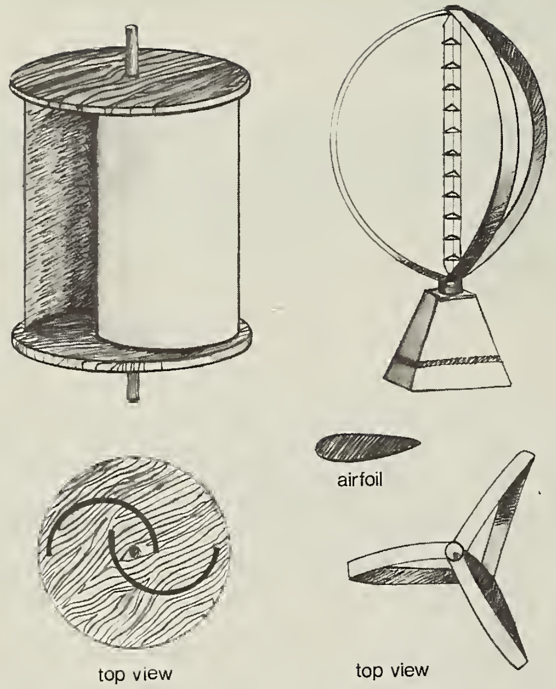
His work is concentrated on two types of vertical-axis windmills, named for their inventors. Because of their vertical axes, wind direction is not a factor in their operation; they can spin as long as air is moving. But each has its own particular advantages. The Savonius windmill, which has two semicircular blades placed in an S-shape between two discs, is a self-starting windmill that is very easy to build. A number have been constructed from oil drums sawed in half lengthwise and mounted facing in



Shown here are two types of vertical axis windmills being studied at the University of Illinois at Urbana-Champaign. The Savonius rotor, left, is self-starting and can be made more easily than the Darrieus rotor, right. But the Darrieus blades, which are airfoils shaped like the cross section shown above, are more efficient. Current work at UIUC is aimed at improving the efficiency of the Savonius rotor.

opposite directions. The Darrieus is slightly more difficult to build because it requires two or three thin symmetrical airfoils (propellerlike blades that are thick in the center and thin at the ends), which are connected in half-circles to the top and bottom of the axis. It cannot start without being given a "push," but it is more efficient than the Savonius, supplying more power for the same amount of wind speed. Both types work under more diverse conditions and are less expensive than the horizontal axis windmill. Richards is focusing on the Savonius, the less efficient of the two, trying to discover the relative importance of various aspects of the design to overall efficiency.

His first task was building a stand upon which he could mount his windmill models in a wind tunnel. After this was completed, he decided on the variations he would build into his Savonius models. They include such things as altering the "bend" of each of the blades, comparing short, wide blades to tall, narrow ones, and modifying the size of the gap between the two semicircular blades (at the point where they overlap in the center of the S). He will observe what effect each of these has on the flow of air and subsequent movement and efficiency of the windmill.

The major consideration in deciding on an appropriate windmill for a particular purpose is that the wind can't be controlled; so the size and type of windmill that will work best depends upon the wind conditions in the individual area.

The use of windmills has been primarily for pumping water or helping provide electric power, and these will probably be its main applications in the future. But if more can be learned about their efficiency, the use of windmills might take a turn for the better. ●

THEY COME IN THREES

Three engineers at the University of Illinois at Urbana-Champaign have received National Science Foundation grants of $17,000 each for on-campus research. They are Professor Larry J. Forney, Department of Civil Engineering; Professor Richard J. Gaylord, Department of Metallurgy and Mining Engineering; and Professor David A. Payne, Department of Ceramic Engineering.

The awards, made to 82 projects selected from 258 proposals, are to assist young full-time engineering faculty members who received doctoral degrees in 1973 or 1974 and have had no substantial research support. They will be a helpful boost for some fresh, new ideas in engineering studies. ●

ONE IN A MILLION

The miracle of life, when viewed analytically, becomes even more miraculous. And in light of the innumerable difficulties involved, its beginning seems almost improbable. An individual spermatozoon is only one-five hundredths of an inch long. During its brief lifetime, it must propel itself over a distance of roughly six inches passing through a mucus and into an oviduct with an opening of slightly more than one-thousandth of a square inch to fertilize an ovum. This is roughly equivalent, on a human scale, to swimming three miles, blindfolded, across a lake to hit an open doorway.

This gives rise to two questions which bother physiologists who study these processes: "Why are so many spermatozoa — on the order of 100 to 500 million — required since only one is sufficient to fertilize an ovum?" and "How do the spermatozoa travel to the oviduct?" Several theories have been proposed to answer these basic and related questions. Professor T. J. Lardner of the UIUC Department of Theoretical and Applied Mechanics is applying analytical and numerical techniques to model the propulsion and transport of spermatozoa with a view toward a better understanding of their physiological functions and related biological experiments. His theoretical analyses of the mechanics of spermatozoon swimming motions have indicated that some theories of spermatozoon travel, while appearing to be physiologically satisfactory, are not consistent with the fluid mechanics of spermatozoon motion.

The spermatozoon propels itself with a thrashing motion of its flagella, or elongated tail, at a rate of one- or two-thousandths of an inch, or less, per second. The precise motion of the tail is not completely known, but it is suspected that it is primarily planar (side-to-side) motion with an occasional rotational component. This would suggest that the spermatozoa would take nearly fifty minutes to reach the oviduct if they were propelled solely by their own swimming motion. Biological research has indicated that they complete the journey in half an hour or less in humans and in as little as three to five minutes in other types of mammals. This suggests that there are other means of transport involved, in particular, contractions of the walls of the tract along which the spermatozoa pass to reach the oviduct. Lardner feels that a number of fluid mechanics problems are suggested by these biological observations.

One reason for the large number of spermatozoa may lie in the process of diffusion. If the spermatozoa travel in more or less straight lines, but in random directions, Lardner's analysis suggests that, of an initial 100 million, only 100 or so may reach the ovum within the span during which they are active. Lardner says that it is tempting to answer the physiologist's question by observing that without large numbers of spermatozoa the number diffusing into the oviduct will be small or zero. However, he cautions, diffusion is only a suggested means of spermatozoon transport.

Professor Lardner, who continues his interest in the biomechanics of reproductive biology which he began as a mechanical engineering professor at the Massachusetts Institute of Technology, is providing a unique perspective which may be instrumental in confirming or disproving various theories of spermatozoon transport. In the process he is contributing to an understanding of some of the more aggravating problems which affect or afflict man- and womankind — overpopulation and sterility. ●

ON THE UP-AND-UP

The average monthly salary of newly graduated engineers from the University of Illinois at Urbana-Champaign has gone up nearly $60 since June. December graduates are averaging $1,059 per month in their first jobs, compared to a $1,000 starting salary for June 1974 graduates. The placement office for the UIUC College of Engineering also reports that of the 188 December engineering graduates, only 11 remain available for employment. Apparently UIUC engineering students are having no difficulty in getting highered. ●

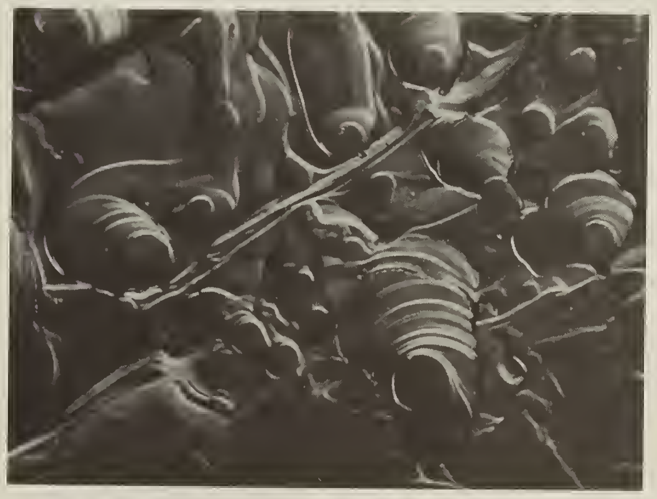
THE BUCK STOPS HERE

One indication of quality in an educational institution is how many research dollars it attracts and spends for its projects. The College of Engineering, University of Illinois at Urbana-Champaign, led the nation in fiscal year 1974 with separately budgeted research expenditures of $18,644,000. When other major engineering-related research is included, UIUC's total is $26,949,000, second only to that of the Massachusetts Institute of Technology.

In the American Society for Engineering Education's latest Engineering College Research and Graduate Study report, 195 engineering colleges and 14 engineering and technical college affiliates reported a total of $468,595,000 in engineering and engineering-related research for FY 1974. Representing 5.7 percent of the total, UIUC's expenditures have apparently proven a worthwhile investment for the varied areas and interests to which they have been applied. ●

PEOPLE AND PLACES

Professor C. P. Siess, head of the UIUC Department of Civil Engineering, was honored with the Arthur J. Boase Award from the Reinforced Concrete Research Council for his "distinguished leadership in concrete research,



This optical interference contrast micrograph confirms certain aspects of a theory of the screw dislocation mechanism of crystal growth being studied by the Department of Ceramic Engineering at the University of Illinois at Urbana-Champaign. Shown here are the growth spirals on one face of a lead tetraborate crystal (400X enlarged 2.8X). Research on this phenomenon will provide a better understanding of the rate at which crystals grow.

teaching, and committee work," and for "success in making research results available and useful to practicing engineers."

The faculty of medicine at the University of Uppsala, Sweden, conferred the degree of Doctor of Medicine *honoris causa* on Professor **Harlow W. Ades,** UIUC Department of Electrical Engineering.

Professor **Hans Frauenfelder,** UIUC Department of Physics, has become the fifth UIUC physicist to be elected to the National Academy of Sciences. He is one of 84 new members elected to the academy this year.

A fellowship from the John Simon Guggenheim Memorial Foundation has been awarded to Professor **Wilson H. Tang,** UIUC Department of Civil Engineering, for a study of the reliability of foundation design, which he plans to conduct in Norway. Tang was one of seven professors at the University of Illinois at Urbana-Champaign and 308 in the United States and Canada to receive the fellowships.

Professor **Martha E. Williams,** UIUC Coordinated Science Laboratory, was elected President of the Association of Scientific Information Dissemination Centers (ASIDIC). Williams has been chairman of the ASIDIC Cooperative Data Management Committee since 1971 and was vice president during 1972-73. ●

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COLLEGE OF ENGINEERING
VOL. 17, NO. 1, AUGUST 1975

inside outlook:

PREVENTING FAILURES AT CONNECTION POINTS IN BRIDGES
DEVELOPING PROSTHETIC BONES FROM PIEZOELECTRIC CERAMICS
DEPARTMENT HEAD NAMED RECIPIENT OF ASEE TEACHING AWARD
PREDICTING EFFECTS OF ACCIDENTAL EXPLOSIONS

WEAR AND TEAR

Some dedicated engineers probably lose sleep because of fatigue around the joints. One team at the University of Illinois at Urbana-Champaign spends at least its daytime hours working on the problem. What the UIUC researchers are concerned with is preventing failures at connection points — joints — in structures, specifically bridges, that are the result of a "wearing out" phenomenon called fatigue.

Fatigue is the repeated shifting and bending back and forth of a material such that it eventually snaps, just as a wire paper clip does when it is repeatedly bent. Truss bridges, the kind that have a series of V-shaped supports on both sides and are usually used as railway bridges, have more connection points that are susceptible to this type of wear than other types of bridges have. At the base of each V, where the two supporting bars come together and are joined to pieces of metal called cover plates, the bolt that joins them fits through holes in the members and holds them together by friction.

The frequent intermittent loading of the bridge as traffic passes over it changes the stress patterns of the members on the joint, and the points which show signs of wear first are those with the least material — the areas around the holes through which the bolts fit. The problem is not safety, since wearing parts can easily be detected and replaced before they give out, but the frequency with which replacements must be made. Variables affecting the wearing of members and how to select the best shapes and materials for them are being studied by Professors D. A. W. Pecknold and W. H. Munse, and graduate researcher Jorge Urzua, of the UIUC Department of Civil Engineering.

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Dealing with the problem empirically is impossible because of the limitless combinations of hole patterns and material types. Instead, Pecknold and his colleagues are developing a computer model which, by defining the problem in terms of certain basic relationships, will enable a computer to determine specific solutions for particular situations. In developing their model, the researchers are studying each joint in terms of the effects of various loads on the stresses produced in the joint by the different members. Inputs including the shape of the piece of material, the location of the holes, the material properties, and the load will yield predictions of the stresses in the joint.

Sometimes one of the supporting members held in place by a bolt slips slightly and the effect of the friction on the stresses is modified. One of the original aspects of the model is its ability to include these changes in frictional resistance in its results.

The model is being designed not for direct use by engineers in designing structures, but as a tool for setting up guidelines for designers. When it is completed, the researchers will run some sample data through the computer, see what results are determined, and decide which variables (such as thickness of cover plates or arrangement of bolts) are important to reducing fatigue.

Hopefully the research, begun about two years ago, will be completed within a month or so. By then everyone involved may be tired out — but fatigue should be less of a problem. ●

BONING UP ON BONES

Life has its ups and downs, and keeping you up is largely the responsibility of bones. Some people stand around all day not realizing how much they take their bones for granted. When they need a replacement part, however, the man-made ones are no match for the natural. Finding a better way to make artificial bone pieces is the goal of combined work in a number of disciplines.

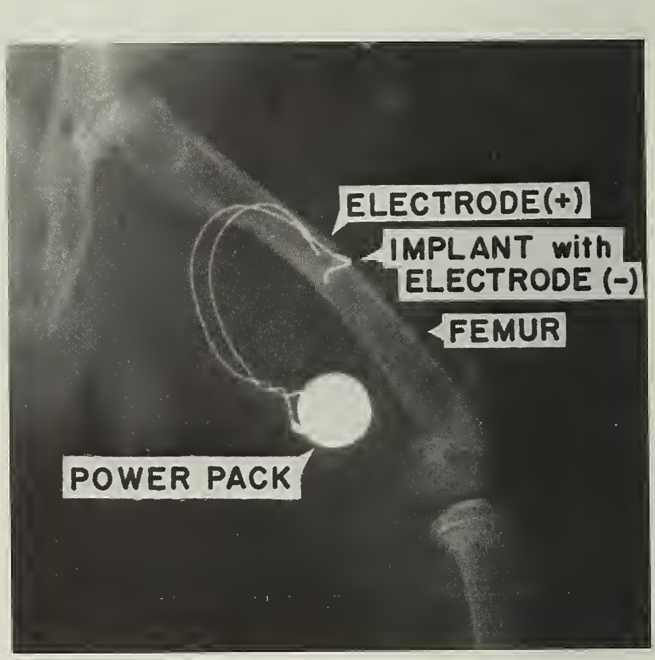
Joints are frequent candidates for artificial bone replacement. In the case of the hip joint, a commonly affected area, the round end of the femur (thigh bone) is cut off, the shaft of the bone is hollowed out, and an artificial piece is inserted. The piece has a shaft of its own which fits down the center of the bone, and a round end resembling the one which has been cut off. These artificial pieces are commonly made of steel, and are held in place in the hollowed-out bone by a glue made of methyl methacrylate (similar to plexiglass).

Ceramic as a material for these replacement bone pieces would be better than steel because it wouldn't corrode, is completely nontoxic and compatible with bone material, and has mechanical properties (responses to bending, stretching, etc.) similar to bone. Thus the bone could become attached to the ceramic implant without using glue, which is somewhat toxic, gives off heat as it solidifies (damaging surrounding cells), and may eventually break up into small pieces that will get into the system and cause adverse chemical reactions. However, the problem with using porous ceramics as artificial bone pieces is the long period of time it takes for the bone to attach itself to them. If the bone doesn't grow into the ceramic material right away, scar tissue could form, preventing proper healing.

A clear solution would be to stimulate the rapid growth of the bone. Experiments have been done which show that electricity can provide this stimulation, because bones themselves emit electrical signals. UIUC researchers are applying that finding in a study aimed at improving prosthetic bones and bone parts.

Two professors in the Bioengineering Faculty, G. H. Kenner, College of Veterinary Medicine, and J. B. Park, Department of Ceramic Engineering, began their project by surgically implanting an electrical power source with wires connected to the femur of a rabbit. They found that the bone grew rapidly around the implanted wire with the growth taking place at the negative electrode. Combining these results with the problems they encountered using the cumbersome power pack and delicate wires in an active body, they came up with a possible answer: a synthetic bone piece made of ceramic material that generates its own negative charge.

Many piezoelectric ceramic materials — so called because they give off an electrical signal when pressed or bent — occur naturally, but they can also be created using a heating and cooling process in an electrical field. A prosthetic bone section made of this material can be polarized, putting the positive charges at one end and the negative charges at the other. After this process, and with the addition of a few pits to allow the bone material to grow directly into the ceramic, the piece would be ready for use, complete with its own rapid-healing mechanism. It would not be likely to be rejected by the body because its physical, mechanical, and electrical properties would "trick" the body into believing it was real bone.



At the University of Illinois at Urbana-Champaign engineers are working with the College of Veterinary Medicine to develop artificial bone pieces which are highly compatible with natural bone. Here an electrical source has been connected to the femur in a rabbit's leg. Bone growth and healing have been stimulated around the negatively charged electrode. Investigators are using this information to create prosthetic bone parts from piezoelectric ceramic material, eliminating the need for an internal power pack.

Kenner and Park are testing this possibility, and are also considering other applications for the idea. They feel that it may eventually allow for the regeneration of teeth, although the constant contact of the wounded area with the outside air would make it more difficult to prevent the formation of scar tissue. They plan to explore ways to solve this problem in future research.

The work of the investigators on improving man-made materials for more compatible use with natural bones clearly has other valuable applications in bioengineering and its related fields. But support should not be difficult to come by, as long as the success holds up. ●

THOSE WHO CAN, TEACH ANYWAY

Professor Bei Tse Chao has been appointed new head of the UIUC Department of Mechanical and Industrial Engineering, and will assume his duties officially on August 21. He is also the 1975 recipient of the Outstanding Teacher Award of the Mechanical Engineering Division of the American Society for Engineering Education (ASEE).

The ASEE honored Chao as "one of those rare engineering educators who is internationally recognized as an eminent scholar and at the same time is acclaimed as a brilliant teacher." In 1973 Chao received the Western Electric Fund Teaching Award from the society's Illinois-Indiana Section.

Chao has been at UIUC since 1948, and for the past several years has been head of the thermal science division of the department. To his current and former students — from neophytes to doctoral candidates — Chao has proved by example that one can deal professionally with things mechanical without allowing one's personality to become the same. ●

BLOW-UP

Though anybody's best-laid plans can go awry, it is especially unnerving if they explode. Unfortunately, the explosions that most of us are likely to encounter, if any, will be the unplanned kind. The precise effects of these variously caused accidental explosions are somewhat of a mystery, even to engineers.

An explosion generates a wave of air called a blast wave, resulting in an increase in air pressure. The amount of the increase over normal atmospheric pressure is called overpressure, and is the principal cause of damage. Low levels of overpressure cause glass breakage; at various higher levels window frames and beams give way and buildings collapse. In "point-source" explosions, where a known amount of stored energy is released instantaneously from a single spot, the effects of the blast wave and resulting overpressure can be predicted. An explosion from a stick of dynamite, for example, is a point source explosion, and will have well-defined effects. But when gas has leaked into a room and someone enters with a lighted cigarette, the occurrence of an explosion is predictable, but its effects are not. In accidental explosions the rate of energy release is unknown; it does not come from a single point, so it cannot be evaluated in terms of point-source theory.

Nevertheless, several engineers at the University of Illinois at Urbana-Champaign are treating the apparent impossibility of these predictions as a challenge. Professor R. A. Strehlow and the three graduate researchers working with him, all of the Department of Aeronautical and Astronautical Engineering, have been working for two years on developing a method of determining the effects of accidental explosions.

Their research centers around identifying and categorizing the different types of accidental explosions. Some of the categories include explosions of containers that break into small chunks (frangible vessels), or tear into large pieces (ductile vessels), explosions that result from the massive leak of a hydrocarbon, such as natural gas, that has been stored under pressure, and runaway combustion that continues after an initial explosion. The UIUC researchers are working on the theoretical considerations, and coordinating their hypotheses with outside researchers who are handling the experimentation.

Complicating the prediction process is the fact that an explosion can result simply from an increase in the burning rate of some materials, if the increase is great enough. In fact, detonation is combustion which travels through a mixture at about seven times the speed of sound, creating a blast wave. Exactly what causes this situation to arise in any given material or combination of materials is still undetermined.

For each of the processes of accidental explosion they have defined, Strehlow's team is calculating the nature of the blast waves and their effect on surroundings, including what fraction of the energy ends up in the atmosphere. While people have always used TNT equivalency to evaluate the strength of explosions ("The blast ripped through the building with the force of an estimated 40 tons of TNT."), the researchers have found that this is not an accurate measurement of the actual blasts. As they get more answers and find more solutions, they plan to put them together into handbooks which will help in assessing the relative danger of different types of accidental explosions.

Meanwhile, the scratch pad and the laboratory are serving as the proving grounds for theories designed to unravel remaining mysteries and explode the myth of TNT equivalency in accidental explosions. ●

PEOPLE AND PLACES

Dean **Daniel C. Drucker** of the UIUC College of Engineering, an honorary member of the world-wide Society for Experimental Stress Analysis, has been named one of its first seven fellows. Also, Professor **Charles E. Taylor**, UIUC Department of Theoretical and Applied Mechanics, was among the first group of regular members to be awarded fellow status. The new designation is for "persons who have been members of the society for at least ten years and who have distinguished themselves through contributions to the art, science, teaching, or practice of experimental mechanics."

Professor **Eugene A. Mechtly**, UIUC Department of Electrical Engineering, was named to the half-time revolving assistant deanship of the College of Engineering, succeeding **Barry J. Dempsey**, Department of Civil Engineering.

The American Society of Mechanical Engineers has selected Professor **George M. Sinclair**, UIUC Department of Theoretical and Applied Mechanics, to receive its first Nadai Award. Sinclair was chosen for his "significant contributions in research, development, and application in the field of materials, especially fatigue and fracture of metals and mechanical testing and failure analysis."

Associate Professor Emeritus **Frank W. Andrew**, UIUC Department of Agricultural Engineering, received the 1975 George W. Kable Award from the American Society of Agricultural Engineers.

Professor **George H. Miley**, UIUC Department of Electrical Engineering and the Nuclear Engineering Program, is one of seventy-two U.S. scientists awarded North Atlantic Treaty Organization (NATO) Senior Fellowships in Science. Miley will go to the Culham Laboratory of the United Kingdom Atomic Energy Authority in England and the Max Planck Institute in Munich, Germany.

Professor **Nick Holonyak, Jr.**, UIUC Department of Electrical Engineering, has been presented the John Scott Award for 1975 from the city of Philadelphia, for his inventions leading to the first practical light-emitting diode.

Professor **Roger R. Yoerger**, UIUC Department of Agricultural Engineering, has been named a fellow of the American Society of Agricultural Engineers.

Professor **B. T. Chao**, head of the UIUC Department of Mechanical and Industrial Engineering, has been appointed technical editor of the *Journal of Heat Transfer*, a publication of the American Society of Mechanical Engineers. He will serve a three-year term.

Professor **Edward C. Jordan**, head of the UIUC Department of Electrical Engineering, has received an honorary life membership in the administrative committee of the Antenna Propagation Society, a part of the Institute of Electrical and Electronics Engineers. This is the second such honor to be awarded by the society in twenty years. ●

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inside outlook:

OXYGEN-BINDING BY HEMOGLOBIN
MULTIVALUED LOGIC COMPUTER
WOMEN'S ENROLLMENT IN ENGINEERING
AUTOMOTIVE BRAKE LINING CLASSIFICATION SYSTEM

ALL IS NOT IN VEIN

The recent heightened concern for health and nutrition has made many people more aware of what they are putting into their bodies. How it gets where it is supposed to go and what it does after it gets there largely depend on the work of specialists — proteins.

Proteins are amazingly complex, and each is designed for a specific purpose. The function of each is determined by the type and arrangement of the twenty kinds of amino acids of which proteins are composed. These are "strung" together, necklace-like, and are collapsed in a particular way, forming a globular structure. The order in which the amino acids are "strung," as well as the way the "necklace" is collapsed, determine the molecule's function and what it is used for.

One often-studied protein is hemoglobin, which picks up oxygen in the lungs and transports it throughout the body via the bloodstream. Another is myoglobin, which stores the oxygen until it is consumed by muscle action. One hemoglobin molecule is essentially made up of four myoglobins, which work together collectively in allowing oxygen molecules into their structures. Professor Hans Frauenfelder, UIUC Department of Physics, is studying the oxygen-binding aspect of hemoglobin, along with Research Assistant Professor Laura Eisenstein and graduate researchers R. Austin and K. Beeson, also of the Physics Department, and Professor I. C. Gunsalus, Department of Biochemistry.

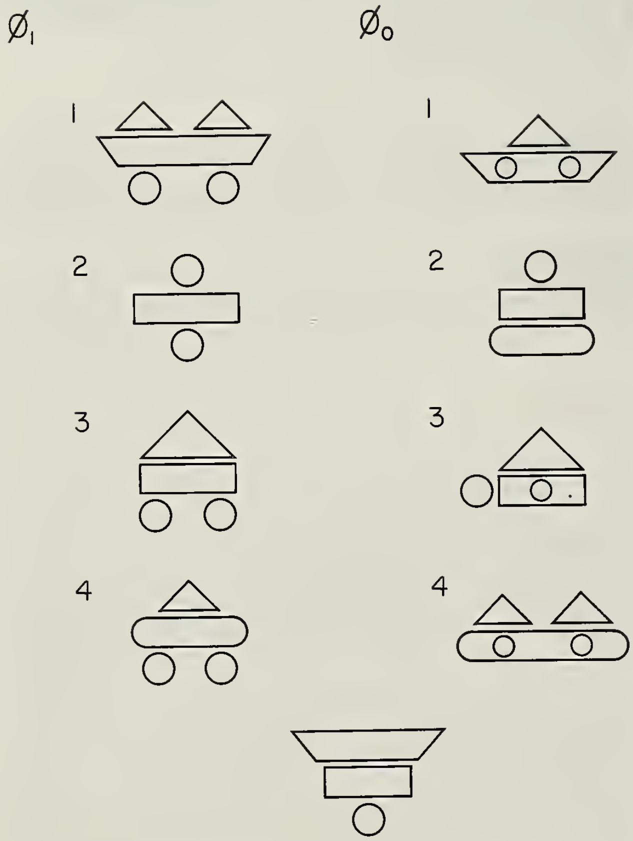
How oxygen enters hemoglobin is not well understood. Until Frauenfelder and his colleagues began their research three years ago, it was believed that oxygen had to pass only one barrier in entering hemoglobin. The UIUC researchers have learned that there are actually four barriers which oxygen has to pass, establishing that hemoglobin is more complex than originally thought.

The experimental approach used in studying this oxygen-binding phenomenon is called flash photolysis. This process involves hitting a molecule which has oxygen already bound to it with a burst of light from a laser. The oxygen is knocked off, and the experimenters then watch it as it rebinds. The temperature range within which the investigation is conducted (−270°C to 50°C) is wide enough to allow the rebinding to occur at different rates, which will give clues about the nature of the barriers. The observation is made easier by the fact that hemoglobin changes to a redder color when oxygen enters, demonstrated by the difference between freshly oxygenated red blood in arteries and oxygen-depleted blue blood in veins.

Although hemoglobin was designed to carry oxygen, it is possible, though much more difficult, for carbon monoxide also to pass the barriers. When it does so, it becomes even more tightly bound than oxygen, and cannot be easily given off. This characteristic makes humans susceptible to carbon monoxide poisoning. An understanding of this binding phenomenon may prove important for preventing such intruders from entering the bloodstream. It may also lead to improved treatment of diseases such as sickle cell anemia, in which red blood cells, rather than being the normal oval shape, are bent in the shape of a sickle, making it difficult for oxygen to enter.

Because there are more than 1000 types of human hemoglobin, the oxygen-carrying capacity varies among individuals. This is usually an inherited situation, though there are many provisions for modification along the evolutionary line, even between parents and children. It is this oxygen-carrying capacity which regulates to some extent the amount of energy one has for physical activity.

The study by Frauenfelder and his colleagues should lead to greater comprehension of how the specialized heme proteins work in their various surrounding structures. At least the conclusions regarding oxygen will be binding. ●



A computer consultant being developed at the University of Illinois at Urbana-Champaign can determine in which column the bottom figure belongs. The computer uses a new logic system, variable-valued logic, to make generalizations from information available to it. One of the first applications of the new system will be as an agricultural consultant serving Illinois farmers. Incidentally, the computer would assign the figure to column $\emptyset_1$ since its bottom element is a circle.

A LOGICAL SOLUTION

It may be difficult to imagine a computer that can take the role of an agricultural consultant, but this kind of computer may soon be an invaluable asset to farmers. Professor R. S. Michalski of the Department of Computer Science and Professor B. J. Jacobsen of the Department of Plant Pathology at the University of Illinois at Urbana-Champaign are developing a computer consultant for plant diseases and pest management. This consultant represents one application of a new kind of logic that Professor Michalski calls the variable-valued logic system.

Unlike the conventional logic system, variable-valued logic assumes that every statement, or elementary observation within it, can accept a different number of "truth values." For example, a statement saying, "Chicago has a population greater than four million people," is either true or false. But the statement, "Senator Smith is doing a good job," can have a number of "truth values:" true, possible, unlikely, or false. Yet another statement may have a different set of truth values which depend on its meaning and purpose. This type of formal logic system will be used as a theoretical tool in the developing computer consultant.

This capability is one more addition to the growing scope of the application of computers. The first application of computer systems was to compute — to make calculations. They were then used to store large quantities of information — to act as a data base. As quantities of information grew to the point where everything couldn't be stored, computers were designed with deductive capabilities. They became information systems that could screen facts and decide which were important to match against given decision rules, in order to give advice. Michalski and Jacobsen are developing a consultant that will also be able to make generalizations from the data and learn the decision rules from the given specific facts that are stored in it. The agricultural consultant is just one example of a computer with this capability. According to the researchers, this logic system can be used to develop any computer consultant, regardless of its final application.

Variable-valued logic is well suited to describing complex real-world situations as a model for decision-making processes. It uses deductive capabilities to apply combinations of facts to situations and then offer a solution. A computer with this type of logic can make decisions, learn from experience, and make predictions. A fully developed machine could be programmed, for example, to give a medical prognosis, or prescribe a remedy or therapy.

The operation of the agricultural consultant will be simple. When it is first used, a farmer will phone in his problem and speak with an operator who will transfer the information into the computer and reply with immediate results. Ultimately, it will perhaps be possible for the farmer to speak to a computer that can understand and act on a human voice. The computer's findings will be drawn from a data base containing information about the various kinds of plant diseases and the conditions that lead to them. Using the computer will be faster and cheaper than waiting for a consultant who must often travel to the farm, get a full explanation, and then reach some conclusion.

There is no limit to the uses of computer consultants for formal decision making if they contain these complex logic systems. In the future, they will have general applicability to science, law, industry, and medicine. Some day, they might even serve as supplemental medical consultants. When you have a cold, you'll phone in your symptoms and the reply will be, "Get plenty of rest, drink lots of fluids, and. . . ." ●

A WOMAN'S PLACE MAY BE HERE

The College of Engineering at the University of Illinois at Urbana-Champaign was one of the first U.S. engineering schools to grant a degree to a woman (in architecture in 1878). But women's enrollment languished until the late sixties; by 1970 there were still only sixty women undergraduates enrolled.

But a campaign of active encouragement began to show results. By 1973, the college was one of only five U.S. schools of engineering with an undergraduate enrollment of 100 or more women. This fall, the college posted a record enrollment of 285 undergraduate women, nearly 7½ percent of the total undergraduate enrollment. Changing attitudes and active support are clearly making it easier to get an Ms. in engineering at UIUC. ●

LINING THINGS UP

The frustration of an automobile that won't start is rather small compared to the danger of one that won't stop. Because of recent federal and consumer-interest pressures for better safety, more and more is demanded of the braking systems that stop autos. The brake lining is a major factor in this system. When this lining, composed of metal and asbestos fibers held together by a resinous binder, rubs against the brake drum or disc in the wheel, the resulting friction brings the car to a halt. But a team of engineers from the University of Illinois at Urbana-Champaign is looking into brake systems in much more detail to develop a classification system for brake linings.

The problem is that brake performance is much more complicated than one surface rubbing against another. As brakes are used repeatedly, they grow quite hot, often as high as 500-800°F. One of the results is that brake linings lose their friction and take more time to bring the car to a halt. Also, there are as many types of linings as there are types of automobiles, and the two must be matched for proper braking performance.

Professors H. E. Cook and R. A. White of the UIUC Department of Mechanical and Industrial Engineering, with the assistance of graduate students George Clark, Joe Sommer, and Len Johnson, are developing a classification system for brake linings to facilitate a proper match. Their classification system should insure that a replacement for a worn lining is suitable for the automobile involved. Since the average brake lining only lasts for roughly a third of the life of the car, a viable classification system will indicate which materials are suitable for cars with different brake system characteristics.

The research procedure of Professors Cook and White begins with dynamometer test results for various linings. The dynamometer measures the torque (stopping power), temperature, and pedal pressure for each type of lining. Existing test procedures would then require that the linings be installed on a number of vehicles which are driven extensively, an expensive and time-consuming step. The UIUC engineers avoid this by feeding dynamometer data on each lining into a computer which simulates varying factors in the braking process such as the highway surface, weather, and driving conditions. The program then predicts the behavior of the linings. In one example, the computer simulates ten repeated stops of a 6000-lb vehicle with a 35-sec cooling period between each stop. It will yield for each stop the temperature of the lining, its torque and friction, and the pedal pressure required to stop the vehicle in a specified distance.

The accuracy of the simulation is being verified with a fully instrumented test car. The car's instruments gauge ten different factors of vehicle behavior and lining characteristics for each stop. The test car will evaluate, under identical conditions, original linings on both sets of wheels, and replacement linings on both sets. Then, under the same conditions, both original and replacement linings will be mixed on the front and rear set of wheels. The results of test car runs will be compared with those the computer derives; success in the study will show a close correlation of findings.

When the computer simulation is verified, brake lining performance can be predicted from dynamometer test data and linings can be readily classified. Automobile manufacturers will be better able to specify suitable replacement linings for their cars, providing for safer driving by putting a stop to bad brakes. ●

This instrumented automobile is used by mechanical engineers at the University of Illinois at Urbana-Champaign in a program to study the characteristics of automotive brake linings. The temperature and braking force at each wheel are monitored along with eight other factors in a project to develop a classification system for brake lining materials.

PEOPLE AND PLACES

The American Chemical Society's 1976 Award for Pollution Control will be given to Professor **Thurston E. Larson** of the UIUC Department of Civil Engineering and the Illinois State Water Survey. The award will be presented in April for his outstanding contributions to pollution control in the U.S., particularly in the area of water quality and treatment.

At its twenty-fifth annual session in Moscow, the International Commission on Irrigation and Drainage awarded **Ven Te Chow**, professor of hydraulic engineering, the commission's Silver Jubilee Commemorative Medal. The medal recognizes his contributions to international cooperation in the field of water resources.

The American Society of Mechanical Engineers has elected **John C. Chato,** professor of mechanical engineering and of bioengineering, to the grade of fellow. This honor was merited by his "outstanding contributions to bioengineering education, measurement techniques for thermal properties of living tissue, and heat and mass transfer processes in biotechnology."

The American Society of Mechanical Engineers has awarded the grade of life fellow to Professors **C. Dale Greffe** and **Kenneth J. Trigger,** both of the Department of Mechanical and Industrial Engineering. The award cites their thirty-five years of service to ASME and the profession.

President Ford awarded a National Medal of Science for 1974 to Professor Emeritus **Ralph D. Peck,** UIUC Department of Civil Engineering. Peck was cited "for his development of the science and art of subsurface engineering, combining the contributions of the sciences of geology and soil mechanics with the practical art of foundation design."

Judith S. Liebman, assistant professor of operations research in the Departments of Civil Engineering and Mechanical and Industrial Engineering, has been appointed to a four-year term on the editorial board of *Health Services Research*. She has also been elected to a three-year term on the Council of the Health Applications Section of the Operations Research Society of America. ●

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COLLEGE OF ENGINEERING
VOL. 17, NO. 3, OCTOBER 1975

inside outlook:

BURST PROCESSING COMPUTERS
HONORS FOR PROFESSOR NEWMARK
ENERGY USE STUDY AVAILABLE
COOLING UNDERGROUND CABLES
THREE NEW COLLEGE APPOINTMENTS

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A BETTER THAN AVERAGE COMPUTER

We are still far from the point where there is no job too big for a computer, but we have already passed the point where the computer may be too big for its job. In this situation, both resources and possibly a great deal of money can be wasted. Professor W. J. Poppelbaum of the Department of Computer Science at the University of Illinois at Urbana-Champaign is conducting research to provide new kinds of processors, called burst processors, which will help in the more practical use of computer time and energy.

The burst processor computer takes the best of both the regular digital and the more unusual probabilistic computer. The regular computer uses a weighted binary system and a microprocessor. This computer must "freeze" information to do its processing, and it is quite complicated. But for all this, its results are very accurate. A probabilistic computer uses the probability of the occurrence of a pulse in a time slot. This probability is judged by waiting a period of time for pulses to occur and then averaging the number of pulses per time period. In a probabilistic computer, which looks at coincidences to reach a conclusion, accuracy is only achieved over a long period of time.

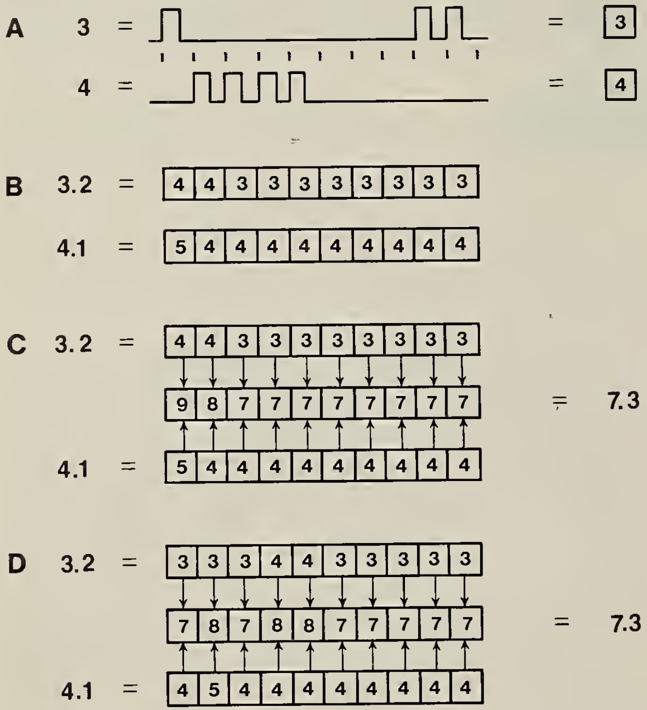
The burst processor lies somewhere in between these two. It uses simple-minded arithmetic on gross approximations and counts on averaging for exact results. It is nearly as accurate as a regular digital computer, and operates nearly as cheaply as a probabilistic system.

The fundamental idea of these simplified computers is the use of burst processing. In burst processing ten adjacent time slots, comprising one frame, are examined by a "reader," and the number to be represented is indicated by the number of pulses (positive signals) in that frame. For example, to represent the whole number 10, there will be a continuous series of ten pulses. To indicate the number four, there will be four filled slots, and six empty ones. The slots are always read in groups of ten, so even if they are read starting at slot number two, there will be three filled slots, six empties, and again one filled; for a total of four, as before.

With burst processing, numbers can be represented to a higher precision by increasing the number of frames scanned from ten to one hundred or a thousand. The average of the individual frames is then the higher-precision information. In adding, burst processing uses the fact that the average of a sum is equal to the sum of the averages. To add 3.2 and 4.1, for instance, we think of these numbers as the average of 4, 4, 3, 3, 3, 3, 3, 3, 3, and 3 and then 5, 4, 4, 4, 4, 4, 4, 4, 4, and 4 respectively, add 4+5=9, 4+4=8, 3+4=7, etc., in a very simple one-digit adder and find that 3.2 + 4.1 = 7.3 is effectively the average of the adder outputs, i.e., 9, 8, 7, 7, 7, 7, 7, 7, 7, and 7. Because of the simplicity of the one-digit adder and the elimination of "freezing" the numbers in certain positions (as in a microprocessor), the cost is very low and the reliability very high.

The best application of burst processing is in situations that don't need the highest accuracy, but require that results must be available in a reasonable amount of time. This is best exemplified by its potential for use in the navigation of naval vessels or for airliners. Instead of having a few computers that keep track of the many components in a ship or airplane, a small inexpensive burst processing computer can be employed for each function. In the long run this can facilitate the operation and upkeep of the equipment.

A computer that is simple and inexpensive to operate will have universal implementation. No doubt, many of these new uses will be found when they burst upon the scene. ●



A computer system using burst processing represents integers by the number of positive pulses occurring in a frame of any ten sequential time slots, as shown in A. Ten frames are needed to represent a two-digit decimal. The number is the average of the ten frames as shown in B. Numbers are added, frame by frame, with a simple single-digit adder as shown in C. The answer is the average of the resulting ten frames. The order of the frames does not affect the correctness of the addition, as shown in D. Burst processing is being explored by UIUC researchers as a means of making more practical use of computer time and hardware.

NEW MEDAL HONORS NEWMARK

The UIUC College of Engineering, the American Society of Civil Engineers (ASCE), and the National Science Foundation (NSF), have all combined to honor one of the college's most widely known and productive scholars, Nathan M. Newmark. Former students and world leaders in his field assembled from four continents to recognize him in a special two-day symposium, sponsored by the college and NSF, on structural and geotechnical mechanics held at the UIUC on October 2-3, 1975. The twenty-two technical papers, presented by authors from the U.S., Canada, Mexico, Brazil, England, Turkey, and Japan, will be published later in a book honoring Newmark.

At the conference, the establishment of a gold medal award in Professor Newmark's name was announced by the ASCE. It will be awarded annually to a member of the society who, "has helped substantially to strengthen the scientific base of structural engineering." The ASCE also announced plans to publish a book of Professor Newmark's professional papers in its "Civil Engineering Classics" series. He is internationally known for his research and studies in structural and earthquake engineering and his leadership in civil engineering education.

Professor Newmark, an alumnus of UIUC, has been a member of the UIUC faculty since 1934, and was head of the Department of Civil Engineering from 1956 to 1973. He has received the National Medal of Science, is a member of the National Academy of Sciences, is a founding member of the National Academy of Engineering, and is a fellow of the American Academy of Arts and Sciences. Among numerous other honors, he has received honorary degrees from Rutgers University in 1955, University of Liege, Belgium, in 1967, and the University of Notre Dame in 1969. ●

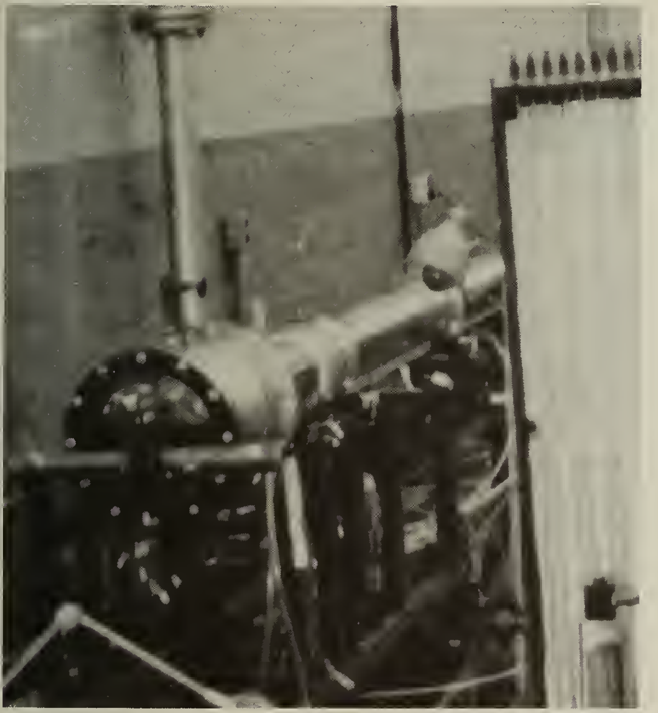
WHERE DOES ALL THE ENERGY GO?

Household energy use is a great deal like the weather, everybody sees it, but relatively few understand exactly how it happens. A team of researchers at the University of Illinois at Urbana-Champaign has published the results of a two-year study that clarify the hows and whys of the household use of energy.

The study, conducted by an interdisciplinary team of engineers, anthropologists, and sociologists, was initiated in 1972 under the sponsorship of the Alfred P. Sloan Foundation to examine energy use in middle-class households. Two surveys were conducted as a part of this study, one in winter of 1972-1973, and one in the spring of 1974. These two just preceded and followed the energy crisis of 1973. The surveys examined the attitudes, values, and energy-related behavior of the population of east Urbana, Illinois, an unzoned, low density area with mixed housing that is typical of many expanding metropolitan populations.

There was a definite response to the energy crisis noted between the two surveys. Increases in gas prices led to a reduction in the number of automobile trips. More persons indicated a willingness to purchase a small car rather than a large one. In the household, where the increased cost of electricity was not as evident as at the fuel pump, there was less of a response to cutbacks. The study also noted a reluctance to make plans for improved housing insulation or to use the public bus system, even in the face of higher energy costs. These attitudes would have a strong influence on future policies to reduce energy consumption.

The complete results of the study, including instrument development, methodological assessment, and base data have been published in a 182-page document, *The East Urbana Study, 1972-1974.* Copies are available at no charge from Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●



This test section of underground conduit has been constructed for experiments in the cooling of underground electrical cables. Improved cooling systems will prevent short circuits and other severe damage caused when cable insulation is ruined by the heat generated from large current loads.

CURRENT RESEARCH

At least one UIUC researcher, when asked how his investigation is going, smiles cheerfully and responds, "Oh, not so hot." Professor John C. Chato of the Department of Mechanical and Industrial Engineering has spent two years studying ways to cool the systems of underground cables that distribute electrical current to major urban areas (*Outlook,* November 1973).

The flow of current through the three cables in a conduit generates a considerable amount of heat. This heat must be transferred from the cables to the surroundings and dissipated, or the insulation will be ruined, resulting in a short circuit and severe damage to the distribution system.

Among the currently available alternatives as possibilities for the cooling system, the best has been found to be the circulation through the conduit of a nonconducting oil that is cooled periodically in a heat exchanger. Professor Chato's research revealed that the position of the cables in the conduit can be made unimportant; they will probably continue to rest on the bottom of the conduit. But the researchers have discovered that changing the angle of skid wires on the cable (skid wires are wrapped around each cable to protect it as it is pulled through the conduit) to about 45 degrees could give better flow characteristics for the oil and also provide stronger anchoring of the skid wires against axial displacements.

The essence of present research by Professor Chato and graduate assistants Rami Adulhadi, S. Y. Chern, R. Ghetzler, and A. Wong is to get the maximum heat transfer from the cables while employing a minimum of power for pumping and cooling. This entire process must be done with simplicity and reliability. The researchers hope to have design criteria for the size of conduit (cable size is more or less fixed), skid wire pitch, and flow rate. They must also identify a good dielectric (nonconducting) fluid with low viscosity, high thermal conductivity, and a high heat capacity.

Another problem confronting them is the nonuniform cooling of cables within the conduit. In experimentation, a test section of underground conduit 10 m (32.8 ft) long has been constructed. Its diameter is about two-thirds of full size in order to account for the entrance effects as the fluid first enters the conduit, before it settles into a steady flow condition.

Although several aspects of the problem will receive additional study, it appears that Professor Chato is well on the way to reducing heat problems in underground electrical distribution systems with his current research. ●

NEW APPOINTMENTS ANNOUNCED

Three new appointments have been announced by Dean Daniel C. Drucker of the College of Engineering.

Dr. Marvin E. Wyman is now assistant to the dean for long-range planning. Dr. Wyman had been chairman of the Nuclear Engineering Program. For more than twenty years, he has been a leader in fission physics and the use of reactors for experimental purposes. He is also a leader in the development of educational philosophy in the field of nuclear technology.

Dr. George H. Miley has become chairman of the Nuclear Engineering Program. Dr. Miley is known internationally for his research in fusion power. He is one of the leaders in a UIUC group which converted energy from a nuclear reactor directly into light without the intermediate use of electricity.

Named as associate chairman of the Program is Dr. Arthur B. Chilton, a specialist in radiation protection and radiation shielding. He is a member of the National Council on Radiation Protection and Measurements and has been a director of the American Nuclear Society. ●

PEOPLE AND PLACES

Professor **Max Anliker,** director of the Biomedical Institute of Technology of the University of Zurich and the Swiss Federal Institute of Technology, was the first "Bioengineer-in-Residence" of the 1975-76 academic year. He presented a public lecture, participated in three seminars, and met with several individuals and groups during his stay on campus.

Professor **Raj Mittra,** Department of Electrical Engineering, has been named as "Distinguished Lecturer" for the Antenna and Propagation Society of the Institute of Electrical and Electronics Engineers. During the next two years he will deliver eight to ten lectures annually to the various chapters of the society in the United States and abroad.

The UIUC Department of Computer Science has announced the establishment of the **Donald B. Gilles** Lectureship in Computer Science. The lectureship was established through memorial gifts by colleagues, students, and friends of Professor Gilles, who died this summer after nineteen years on the UIUC faculty.

Professor **J. J. Dorning,** Nuclear Engineering Program, has been awarded a National Research Council Visiting Professorship by the Committee for Mathematical Science of the Italian National Research Council. He will spend the six-month appointment at the University of Bologna doing research in plasma physics, reactor theory, and the kinetic theory of rarefied gases.

The UIUC Dad's Association has recognized Professor **James W. Bayne,** associate head of the Department of Mechanical and Industrial Engineering, with the association's Certificate of Merit. The award cites his "competence as a teacher, broad and varied interests, and assistance in campus orientation programs and off-campus meetings with parents and prospective students."

The 1975 Windsor Lecture of the UIUC Graduate School of Library Science has been given by Professor Emeritus **Heinz Von Foerster,** Department of Electrical Engineering. The lecture is in memory of Phineas L. Windsor, director of the UIUC Library from 1909 to 1940. ●

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inside outlook:

- CONTINUING RESEARCH ON SUBATOMIC PARTICLES
- A NEW TSUNAMI WARNING SYSTEM
- CAVITY DESIGN FOR CHEMICAL LASERS

A PUZZLING PHENOMENON

It very often seems that the universe is one giant puzzle. But in addition to making all the pieces fit, the scientist frequently faces the more difficult task of first finding the pieces. The puzzle of the composition of matter was recently changed by the discovery of two new subatomic particles. These particles are now found to be part of an entire family of particles that has very unusual properties. The analysis of these new particles is the work of Professors G. Gladding, M. Gormley, R. Messner, T. O'Halloran, and A. Wattenberg of the Department of Physics at the University of Illinois at Urbana-Champaign. They are attempting to discover as much as possible about these particles, and then fit them into their rightful place in the puzzle.

Researchers have found that these particles are very massive. This is unusual because, with the large amount of energy they possess, they should tend to break up, and not remain intact. These particles also live an unexpectedly long time for their size.

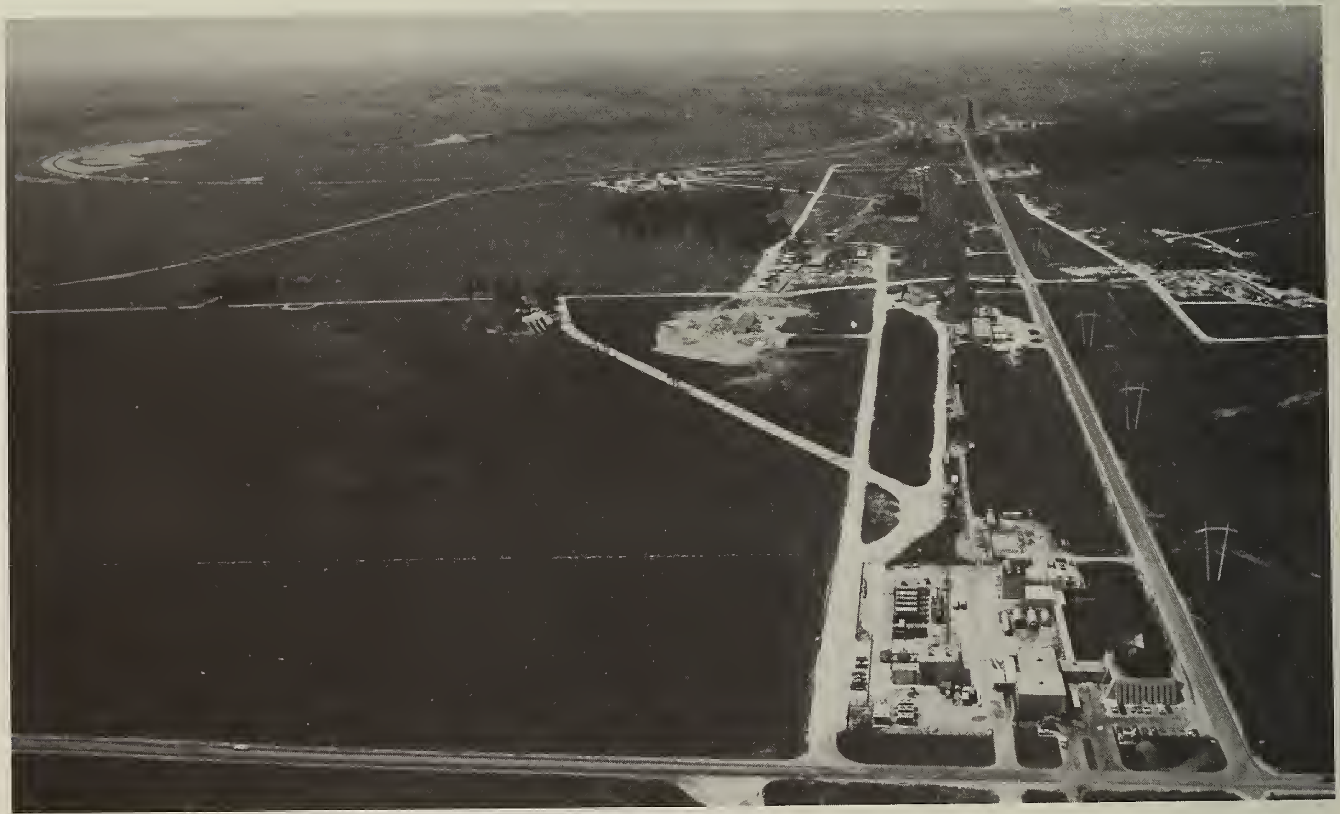
Experiments for finding more massive particles had been set up at the university in 1971, in cooperation with Columbia University and the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois. Two years were spent in building, testing, and installing equipment at Fermilab, and experiments had been begun when news of these newly discovered particles broke in November 1974. Because the equipment had already been assembled, UIUC researchers were in an excellent position to conduct studies.

The unique aspect of these studies is the use of a high energy "beam of x rays." This beam has the power of up to 200 billion electron volts (BeV); normal x rays are a few hundred thousand electron volts. The collaboration has found that if matter is bombarded with these x rays, these new particles will emerge. The fact that the particles come directly forward indicates that they are similar to x rays, but that they have a mass. This limits the number of theoretical explanations of these particles, and other previous possibilities proposed by theorists. But the discoveries did confirm that the particles are unusual, and unlike any particle with which scientists are currently familiar. These mysterious particles are the stimulus for new theories which may lay the groundwork for innovative perspectives in particle physics.

Evidence about the particles is pointing in a specific direction. In the 1950s and 1960s physicists began knocking apart neutrons and protons. Models were developed in which the neutrons and protons were made up of three basic building blocks, called quarks. The validity of these models was brought into question by experiments made two years ago. Because of this, the most popular explanation of these newly discovered particles is that they are built up out of a fourth type of quark. But this means that the entire picture of the structure of matter has to be modified. The old models must be changed to accommodate the new particles.

Years ago there were only a few detectors used in such experiments. Today there may be 6000 or more detectors in a single system. They are interphased into a medium-sized computer, so data can be analyzed at the time they are taken.

The research procedure involves a variety of different types of equipment. This experiment (run by the Energy



UIUC particle physicists are experimenting on a grand scale using the facilities of Fermilab (Fermi National Accelerator Laboratory) at Batavia, Illinois. In this view of Fermilab, the main accelerator ring in the upper left provides high-energy beams which are deflected to various experimental areas in the foreground and middle distance. The diameter of the main accelerator ring is 2 km (1.3 miles) and the distance from it to the experimental area in the foreground is 2.5 km (1.5 miles). (Photo courtesy of Fermilab)

Research and Development Administration) is performed in an underground pit. A room 46 m (150 ft) long is used and the apparatus are spread along it. Because the position and paths of the particles must be measured accurately, the precision of the measurements is to one-one hundredth of an inch. There are nearly 650 km (400 miles) of wire leading from the pit to the computer 15 m (50 ft) away (all of it placed, incidentally, by graduate students and staff). In order to obtain these powerful x rays, Fermilab had to construct possibly the longest cryogenic system in the world, consisting of 30.5 m (100 ft) of liquid deuterium, which acts as a filter to get rid of neutrons that are emitted in the same process that forms the x-ray beam.

Due to these recent discoveries, it seems that the exact composition of matter will continue to be unknown for the time being. But now that it is known that these new particles exist, there are two new pieces for the jigsaw puzzle of particle physics. ●

NOBODY'S FRIEND

The last three letters of the word "tsunami" is the French word for friend, *ami.* But the tsunami is no friend to those living in coastal areas susceptible to their destructive capabilities. A tsunami is a very long sea wave (around 200 km, 125 miles) which is caused by an earthquake on the ocean floor. To prevent the possible high loss of lives, it is necessary to have a warning system that is effective and reliable. This system is currently the major component of the research in marine geodesy by Professor Narendra Saxena of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign.

The concept of marine geodesy, first formulated in 1965, is to extend surveying measurements from solid earth into water. It defines and establishes control points in or on the ocean, and maps the shape of the ocean including its floor. It is more difficult than traditional surveying for several reasons. Because of the relatively large distances involved, the ocean must be treated as a curved surface, not a flat plain. Line-of-sight observations, the basis of traditional surveying, are not possible except in clear, relatively shallow water. Finally, it is not possible to transmit information by radio or light waves; all underwater transmissions must be through the use of acoustics — sound waves.

A tsunami is a rare phenomenon caused by an earthquake occurring in water 1800 to 5500 m (5900 to 18,000 ft) deep. The maximum height of this long sea wave is 10 to 50 cm (4 to 20 in.). In mid-ocean these waves have no effect on ships, and they often disintegrate as they move. But if they spread into more shallow waters their energy is compressed into a shorter, higher wave (heights can be up to a few meters). To prevent destruction, warnings must be given to areas that are potential targets. The most dangerous of these are near the Pacific earthquake belt, the Alaskan Aleutian Islands, the Russian Kamchatka-Kurile Islands, and the Japanese Hokkaido-Honshu Islands.

The current Tsunami Warning System uses seismograph readings on motions of the earth's crust under the oceans. A submarine earthquake, registering seven or more on the Richter scale can lead to the formation of a destructive tsunami. The system's headquarters in Honolulu tries to locate where the tsunami has occurred, and then alerts the coastal area in danger. These areas also report back to Honolulu readings from tide gauges on sea level changes. The problem is that two-thirds of the warnings from the system are false alarms; the wave dies before it ever reaches the coastline. A good warning system must use the seismic wave information and be able to measure precisely the small height of the tsunami in the deep ocean. It would then be possible to predict accurately whether or not the tsunami will approach the shore.

The warning system that Professor Saxena proposes will supplement this present system. There are three components to his system. The first is a series of complex acoustic stations placed on the ocean floor in and around the earthquake belt area. The second component is a series of buoys, each floating directly above an acoustic station. At the bottom of each buoy is an instrument for picking up sound waves sent by the station beneath it. On top of the buoy is instrumentation to convert the information to radio waves which are transmitted to a satellite, the third component. The stations on the ocean floor will be able to report its position and the time it takes the wave to pass over it. A series of stations can then check height, velocity, and direction of a tsunami as it approaches the shore. The information is transmitted (after being converted by the buoy) to the satellite which sends a signal to the center in Honolulu. The warning center can then disseminate information about the tsunami to areas in danger.

The essential element of the system is the precision of the location and measurements of the station and increased knowledge of the shape of the ocean's floor. The former permits a more precise calculation of the energy of the wave. The latter allows accurate prediction of how the energy will be compacted to turn a harmless wave into a destructive tsunami.

An operational warning system can prevent a great deal of loss to lives and property. Therefore, a system such as this will be most welcome to those who will wave goodbye to destructive tsunamis. ●

TRAPPING THE LIGHT FANTASTIC

The presence of a cavity in most structures usually results in one problem — filling it. The most painful example is filling a cavity when it forms in a tooth. In contrast to this, rather painless research is being conducted at the University of Illinois at Urbana-Champaign on the design (not the filling) of the laser cavity in a chemical laser system.

A chemical laser consists of a series of flowing streams of materials such as fluorine, deuterium, or hydrogen. These streams react together and form a "species" of excited molecules that will lase — give off coherent light. This light is then collected by mirrors to form a coherent beam. Professor A. L. Addy and graduate assistants Clark Mikkelsen and Mark Sandberg of the Department of Mechanical and Industrial Engineering are concerned with the gas dynamic problems associated with the design of the laser nozzle, cavity, and pump in which the combustion and amplification take place.

The gases inside the cavity are accelerated to supersonic speeds to produce a low cavity pressure necessary for the lasing process. To help maintain the low pressure there is an ejector that works in a manner similar to a pump, but it has no moving parts and is not affected by the gases. However, the ejector presents many problems because it has never been applied to lasers. A new type of ejector was designed specifically for use in chemical lasers to maintain a low cavity pressure while increasing the efficiency of the laser system resulting in an increased power output through greater utilization of the energy potential of the chemicals involved.

Other problems are related to the laser cavity. The shape of the cavity determines whether or not lasing occurs. After emitting light the gases must be properly ejected. The mirrors present problems because they must be protected from chemical reactants; after the chemicals have lased, their flow must not get into the mirror cavity. Once all these problems are solved, work can begin to reduce the size of the system.

The research procedure involves models of ejectors and a laser cavity. Hydraulic analogies are used to simulate the total system. Instead of using chemicals, a flow visualization using water comprises the analog system. Air models are also used for simulation purposes.

Once the technique is perfected, a functional chemical laser system will produce energy output superior to any laser system currently in use. This energy can be used for machining, mining, fusion processes, and possibly for airborne applications. Doubtless there will be additional uses for the laser cavity, taken as a whole. ●

PEOPLE AND PLACES

The Society of Die Casting Engineers Chapter Citation has been presented to Professor **James L. Leach** of the UIUC Department of Mechanical and Industrial Engineering. He was cited for his work in furthering the education to advance the art and science relating to die casting.

A three-year, half-million–dollar contract with the U.S. Department of Transportation has been awarded to the University of Illinois at Urbana-Champaign to develop statistical and mathematical models for estimating failure probabilities of transportation systems and their components. The principal investigator is Professor **Alfredo H-S. Ang** of the Department of Civil Engineering.

Professor **Floyd Dunn** of the Department of Electrical Engineering is spending a year at the Institute of Cancer Research in Sutton, Surry, England, under an American Cancer Society–Eleanor Roosevelt International Cancer Grant. While on leave he will be doing research on the use of ultrahigh-frequency sound in locating and studying cancer.

The National Science Foundation has awarded the Department of Civil Engineering a $476,500 grant for research on building design to protect against such hazards as earthquakes and high winds. Professors **Nathan M. Newmark** and **William J. Hall** will lead the research team. ●

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inside outlook:

NEW RESEARCH ON MODES OF TRANSPORTATION
AN ECOSYSTEM MODEL
USING RICE HULLS
THE DYNAMICS OF OCEAN STRUCTURES

TRANSPORTS OF DELIGHT

A collection of art objects is an aesthetic pleasure. A coin collection can trace a nation's history through its monetary system. But, until recently, collections of accident statistics have only been used retrospectively as reminders of the casualties involved in past accidents. These statistics will hopefully have more meaning upon completion of research made possible by a grant of the U.S. Department of Transportation to a team of UIUC engineers.

This grant will support a three-year half-million-dollar study by an interdisciplinary research group led by Professor A. H-S. Ang of the Department of Civil Engineering. The expertise being devoted to this project is considerable. Researchers from the Department of Civil Engineering include John E. Baerwald, director of the college's Highway Traffic Safety Center, and Professors W. W. Hay, Wilson Tang, and Y. K. Wen. From the Institute of Aviation, C. O. Hopkins, head of the Aviation Research Laboratory, and Professor M. J. Kelly will participate. Other investigators include J. J. Desmond, associate director of the Engineering Experiment Station, R. G. Mortimer, professor of health and safety education, and Robert A. White, professor of mechanical engineering. The researchers aim to develop a quantitative method for predicting accident rates for the three major modes of transportation: air, highway, and rail.

No such technique presently exists. A great deal of data has been collected over many years; the goal of this project will be to make use of much of this information in the development of systems risk models. Each of the major risk-contributing components of a system (human, mechanical, and environmental) and its respective role in a transportation system will be identified and analyzed.

The identification of major risk factors and hazard components can be used by designers of transportation systems to help them evaluate the expected safety of future systems. Existing transportation systems can also be better understood and improved. A perfect transportation system is still a long way from completion, but specific safety information is an important ingredient in determining the trade-off between cost and safety.

The techniques involved in the project will be based heavily on the concepts of risk analysis and probability and reliability theory. The research team will devise the necessary theoretical models and incorporate results of data analysis to establish a quantitative method for systems safety evaluation. The same concepts will be used throughout; however, a separate model will be required for each mode of transportation.

Although other analyses of accident statistics have been conducted, this study will examine the data in the most comprehensive fashion to date. Instead of concentrating on one element of the system, as in automotive safety, the researchers will examine all the elements of the total system — vehicles, drivers, the roadway, the surrounding environmental factors, and the like. Perhaps most importantly, they will try to determine the relationship between these elements, so future planners of air, rail, or highway transport systems will have a better understanding and control of systems safety. This research will hopefully produce statistically significant results to reduce this significant collection of statistics. ●

AN EXAMPLE OF MODEL BEHAVIOR

The construction of model autos, airplanes, ships, and railroads poses a challenge that usually ends with the completion of the model. But a researcher from the UIUC Institute for Environmental Studies has completed a model ecosystem whose challenge has just begun. Robert L. Metcalf, professor of biology and entomology, has constructed an ecosystem, a "slice of the environment," in which he studies the fate of pesticides and a variety of other chemicals.

Factors in the environment are constantly changing the chemical composition of a pesticide. It can be altered by sunlight, reactions with water, or by enzymes in an organism. It is important to know about the properties of each pesticide in order to determine if they will be dangerous. The most important of these properties is how the pesticide ends up in the environment. The more fat soluble it is, the more a pesticide tends to get into and remain in tissue. The greater the presence in tissue, the greater the danger to plant and animal life. It is inconsequential that the remaining quantities are very small. They are still dangerous because they can be passed along to other organisms through food chains and bioconcentrated to much higher amounts. Man is particularly vulnerable because he is at the top of the food chain.

When the research began, Metcalf studied fifty pesticides which were tagged with radioactive compounds so they could be traced. Through the life cycle of the ecosystem, which is constructed in a fish tank, he could trace the path taken by the pesticides through the ecosystem's components. First, plants are treated with a pesticide. Caterpillars in the model eat these plants. The caterpillars and their excrement then fall into a small body of water that is part of the ecosystem. All the elements present in a lake (such as algae and other small organisms) have been provided for in the model. Fish are then placed in the tank to complete the food chain. The various elements are now examined to see how much of the pesticide remains, and the form which it has taken.

This work with pesticides was found to be so useful that an ecosystem is currently being applied toward research with other chemical compounds. Investigations are being conducted on how animal feed additives affect the environment. Researchers would like to know if any chemicals in the food additive are retained by the animal. They would also like to know if any portion of the chemical is present in excretions of the animal, and if so, what happens when the excrement in a body of water is taken in by fish.

This fish tank contains a model ecosystem. The model, constructed by researchers at the UIUC Institute for Environmental Studies, enables investigators to trace a chemical through an entire food chain to examine the effects of pesticides and other chemicals on the environment and the organisms living in it.

Studies are being conducted to find out about carcinogens that might get into food and food packaging. Another interesting study is looking at the chemicals that might remain after the energy transformation that takes place in a coal gasification project. Large amounts of chemicals are produced when coal is processed, and it is necessary to look at the products remaining in the ecosystem, particularly those that are not degradable. Model ecosystems can be used to check what happens to any agricultural or industrial chemical, and to find out where it goes once the cycle is over.

The model ecosystem is invaluable in this type of research for several reasons. It is possible to introduce a specific chemical and watch as it goes through various products. The researcher can be using higher concentrations of radioactive material than could ever be used in a real environment. And model ecosystems make it possible to simultaneously study many compounds (because they are relatively inexpensive to use), providing a comparison among alternative pesticides.

The model ecosystem can prevent harmful, and possibly irreparable damage to the environment. It is an efficient and economical way to measure and predict what will happen to chemicals when they pass from one element in the food chain to the next. Proper utilization of the results will prevent compounding the damage that might otherwise occur, including preventing pesticides from making a pest of themselves. ●

USING RICE TWICE

In a world situation where scarcity is increasingly more commonplace than abundance, care must be exercised to ensure that as few natural resources as possible are wasted. Many elements and products found in nature can be put to better and more efficient use. One such material is the rice hull, and research on its use is being studied at the University of Illinois at Urbana-Champaign by graduate student Nirmal K. Sharma, under the supervision of Professor Wendell S. Williams, Departments of Ceramic Engineering and Physics.

After rice is milled, the hulls remain. Because the hulls contain silica, they are not biodegradable. In a country such as India, where rice is a major foodstuff, this causes a considerable problem as literally millions of tons of hulls accumulate annually. Since it is environmentally unsound (and illegal in the U.S.) to reduce their volume by burning, the remaining alternative is to find a use for them.

Carbon is also an important constituent of rice hulls, and the original research goal was to extract this carbon. Preliminary work showed that extraction was impractical. Therefore, the carbon and silica were studied together, because, when the two are combined they form silicon carbide, a hard material with a high melting point. Silicon carbide is used in turbines, furnace linings, and cutting and grinding wheels.

Although silicon carbide has been made previously from rice hulls, the Illinois research team found a way to improve its quality. By adding a chemical element at the appropriate time, the reaction is catalyzed, or speeded up, providing a more economical way to manufacture the silicon carbide. With the large quantities of rice hulls involved, this becomes an economically important discovery.

Additional studies with a scanning electron microscope have enabled Sharma and Williams to locate the silica exactly in the rice hull. They have found that it is not uniformly distributed in the hull; some is on the inner surface — in contact with the kernel of rice — and some is located on the outer surface of the hull. This characterization of the raw material is a contribution by engineers to the field of plant physiology.

Discoveries such as these are important to the United States, and even more so to developing countries. These new findings turn otherwise useless waste into useful new products. This solves the problem of disposing of a wasted material, and it creates opportunities for a new product to be used in manufacturing and industry. ●

HITTING A HIGH SEA

Although the tunes they play are quite different, a violin string and an off-shore drilling rig can both vibrate. But the vibration that produces music in one case, can lead to disaster in the other. An engineer at the University of Illinois at Urbana-Champaign is studying these massive structures to learn why.

Off-shore drilling structures, large platforms supported by three or four legs, were built in relatively shallow water (100-200 ft) until the search for submarine oil and gas pushed them farther from the shore. By the mid-sixties, platforms were constructed in water depths of nearly 400 ft; by the mid-seventies, some had reached a depth of 500 ft or more.

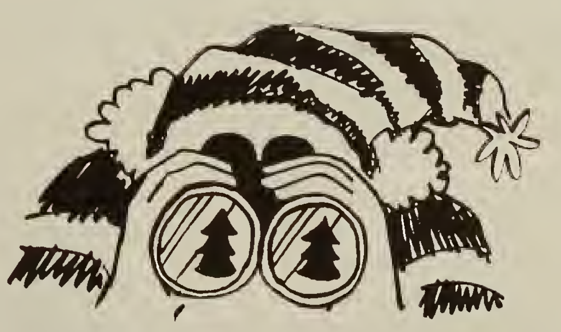
As the depth of the water increases, the way in which structures react to ocean waves changes. Instead of a static response — a tendency to bend slightly when a force is applied — they show a dynamic response — an oscillation. Professor J. P. Murtha of the UIUC Department of Civil Engineering is studying this situation to see exactly how this dynamic response will affect the design of future off-shore structures.

Ocean waves which seem to be random may actually contain fairly regular waves moving in different directions with different times between their crests, referred to as the period of the wave. The effect of these waves on the shorter structures used in the past was primarily static. This is a fairly well-known phenomenon for which there is a well-developed body of engineering theory.

But structures constructed for deeper water may react to the waves much like a giant violin string, they vibrate. Because of their large size, they vibrate very slowly, about once every 5 to 7 sec, depending on their construction and exact length. If repeated waves with a similar period of 5 to 7 sec strike the structure, they make it vibrate or oscillate more intensely. If the oscillations become sufficiently large, the structure may be damaged.

To learn exactly how this happens, Professor Murtha is subjecting scaled-down models of simple components to a series of random waves and examining their response, using a wave generator in a 150-ft wave tank. The models' responses are measured and compared with theoretical predictions. These results can be scaled up and applied to larger components of actual structures. The final results will be a set of characteristics and guidelines which can be incorporated into the design and construction of actual drilling rigs to minimize the structures' dynamic response to waves.

Although his research should shed new light on the behavior of ocean structures, the final design of drilling structures will be based on actual conditions in the sea. However, with the help of Professor Murtha's research, drilling can continue to delve into deeper waters, farther from shore. And, as least as far as the structure's component parts are concerned, there will probably be less fiddling around. ●



SEASONS GREETINGS

from the engineering lookout

PEOPLE AND PLACES

President Ford has named Professor **Nathan N. Newmark** of the UIUC Department of Civil Engineering to be chairman of the president's committee on the National Medal of Science. The committee assists the president in selecting for the national honor persons who "are deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical or engineering sciences." Newmark has been one of the twelve appointed members of the committee since 1972. He also received the medal in 1968.

Professor **S. L. Soo**, UIUC Department of Mechanical and Industrial Engineering, has received a Fulbright-Hays award to lecture at the National University of Buenos Aires, Argentina, next summer. He was selected by the U.S. Board of Foreign Scholarships and the State Department and will lecture on thermodynamics.

Professor **Martha E. Williams**, UIUC Coordinated Science Laboratory, has been named to the computer networking committee of Engineering Index, Inc. Williams is a trustee of the corporation.

Professor **Donald Day** of the UIUC Department of Agricultural Engineering was one of the featured speakers at an international seminar on refeeding processed livestock wastes held in Moscow, U.S.S.R. The seminar was sponsored by the U.S. Feed Grains Council. Day was one of six speakers chosen by the council from the United States to address the topic of processing and utilization of livestock wastes as nutrients in animal diets.

Professor **Raj Mittra** of the University of Illinois at Urbana-Champaign has been elected president of the Antenna Propagation Society of the Institute of Electrical and Electronics Engineers, to take office in January. Mittra is currently associate director of the Electromagnetics Laboratory in the UIUC Department of Electrical Engineering.

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COLLEGE OF ENGINEERING
VOL. 17, NO. 6, JANUARY 1976

inside outlook:

ACCESS TO DATA BASES
WITH NATURAL LANGUAGE PROGRAMS
AUTOMATED DAIRY FEEDING SYSTEM
1976 ENGINEERING OPEN HOUSE
COMPUTER-GENERATED HOLOGRAMS
THE SUMMARY OF ENGINEERING RESEARCH 1975

SPEAKING WITH COMPUTERS, NATURALLY

Computers, for all their benefits to humanity, are still very quick idiots with perfect memories. They must be carefully told what to do and exactly how to do it. And although they can store massive amounts of detailed information, access to this information requires considerable skill and a deft touch, since one must think like a computer and speak the computer's language to retrieve information.

This barrier to communication is being attacked by a UIUC engineer who has posed an interesting approach to the problem of getting at data stored in a computer. He is demanding that the computer think and listen to instructions like a human.

Professor David Waltz of the UIUC Department of Electrical Engineering and the Coordinated Science Laboratory is formulating an intelligent program which accepts natural language queries (questions in conversational English) that will allow a nontechnical user to obtain information from a large data base. His system will hopefully allow the user to talk to the computer rather than program it, allowing the computer to understand questions about the particular data base stored in it and to provide answers to these questions.

The problem Waltz is studying is a complex one. First, the computer must understand what is being said. It must understand the various parts of a sentence and adequately relate them to its own understanding of the data base. Then it must be able to assemble parts of the discussion in a way that will create a reasonable data-base search routine.

Second, the computer must understand what hasn't been said, but what is understandable from the context of the discussion and the correct sentence. It must tolerate pronouns and other referential phrases.

Finally, the computer must know when it is failing to understand what is being asked. In essence, it must be able to ask, "What?" The computer traps questions containing errors and restates the request as the computer perceives it. The machine can ask a clarifying question or it might state that the request is meaningless or not possible.

The first step in Waltz's system is to structure the data base so it can be readily searched. A basic system description, similar to a blueprint, has been developed, making it possible to look at the data base to see its contents.

The data-base search functions of the computer correspond roughly to English sentences, so the constraints of conversational English naturally play an important role in the function of the system. Most inquiries are broken up into rather simple terms. For example, the question, "How many times have generators failed in two-seater aircraft which crashed in May?" is broken into two segments. The first is "Which two-seater aircraft crashed in May?" And the second, "How many times have generators on these aircraft failed?" Each of the simpler pieces is then matched with sentence skeletons stored by the system. The skeletons can match phrases, so it is not necessary for the questions to be grammatically correct. In this way the system also embodies a certain amount of "common sense."

The Library of the
JAN 30 1976
University of Illinois
at Urbana-Champaign

The current data base contains aircraft maintenance and flight statistics — how parts malfunction, why, and what are the likely results of a particular maintenance action. Hopefully, users of the question-answering system will be able to quickly spot patterns and common factors in these maintenance data to identify failure-prone aircraft.

One current problem is determining how many skeletons are needed for a system to be functional, and how they can be compactly stored but easily retrieved.

The completion of the natural language access to a large data base will be valuable to individuals working in the sciences, business, and industry. It will be particularly helpful for those with limited computer programming skills. Finally, man and machine will be speaking the same language, and in this case, it will be English. ●

```
*  WE WERE TALKING ABOUT THE CHEROKEE AIRCRAFT.
         YES.

*  HOW MANY REQUIRED UNSCHEDULED MAINTENANCE IN APRIL?
         THREE CHEROKEES.

*  DID ANY OTHER PLANES NEED MAINTENANCE?
         DURING WHAT TIME PERIOD?

*  APRIL AND MAY.
         YES, A TWIN BEECH.

*  IN APPL?
         DO YOU MEAN APRIL?

*  YES.
         YES.

*  IS IT TRUE THAT IN ALL FOUR CASES AND APRIL FLIGHTS THAT
   OCCURRED ON THE FUSELAGE?
         I CANNOT UNDERSTAND YOUR QUESTION.  IT IS
         UNGRAMMATICAL AND MEANINGLESS.

*  DID ALL FOUR CASES IN APRIL INVOLVE WORK ON THE FUSELAGE?
         YES.

*  AHA!
```

This sequence of questions and answers is an example of the interchange between a user and a computer with a natural language data base. Computers of this type are being studied at the University of Illinois at Urbana-Champaign. Researchers at the UIUC Coordinated Science Laboratory are developing this type of system using English as the natural language.

BALANCING BOVINE DIETS

Anyone who is concerned with nutrition and diet knows that it is indeed a challenge to monitor and regulate food intake. One source has estimated that more than a third of the American population is overweight. But while man must continue to control this process for himself, a group of researchers has been solving the problem for dairy cows by the invention of an electronic cow feeder system. This work at the University of Illinois at Urbana-Champaign combines the expertise of Professor K. E. Harshbarger of the Department of Dairy Science, Professor E. F. Olver of the Department of Agricultural Engineering, and Professor H. B. Puckett, a research collaborator from the United States Department of Agriculture.

Cows consume two kinds of feed. The first type is forage, feed that is high in fiber. Forage may be the whole plant of hay, silage, or pasture. This is usually supplied to the cow on an unlimited basis, and the cow can consume as much as she desires without danger of eating too much or of having this consumption become too expensive. The more concentrated portion of the diet is harvested grain. The amount of grain each cow consumes must be limited to an optimum amount which supports maximum milk production. Cows favor grain over forage, but it would be both uneconomical and unhealthy to allow them to eat as much as they want.

The electronic feeder provides an automated system for dispensing these grains. The system operates through the use of a transponder on the cow's neck and instrumentation within each feeding stall. The transponder is set for a specified amount of grain the cow should eat per day (based on either a twelve- or twenty-four-hour feeding cycle). When the cow enters a stall, she places her head through a loop antenna which receives radio signals. There is a constant signal between the transponder and an interrogator in each stall. Each transponder contains a device which acts as an electrical equivalent of a well-fed cow. When this device is fully charged, the grain meter automatically stops feeding the cow. A smaller number set on the transponder results in a short feeding time; a larger number allows the cow to be fed a greater amount of grain. Once the device is charged, it discharges over a twelve- or twenty-four-hour period, indicating the electrical equivalent of increasing hunger. This is another way of placing a constraint on the amount of grain each cow consumes.

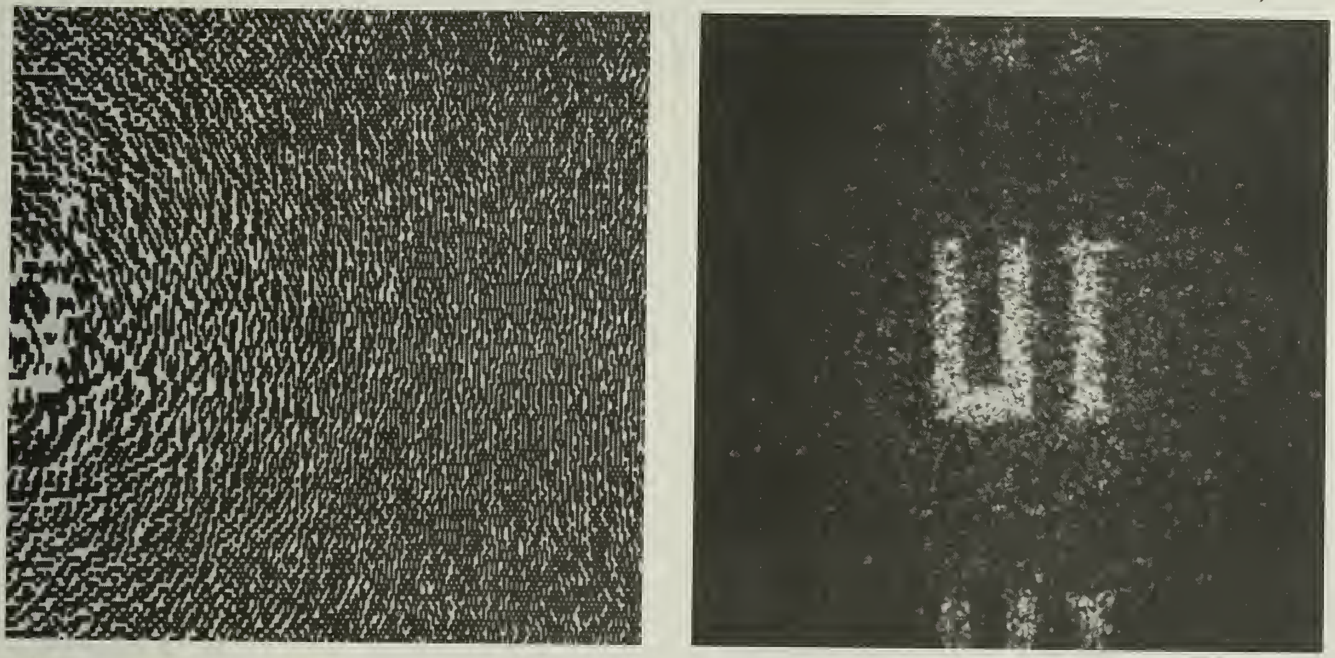
The electronic feeder can be adjusted to vary the amount of grain fed to the cow each minute. But a critical point is estimating the cow's eating rate. She should be eating the grain as it is delivered. If the rate is too high the cow might leave the stall with a considerable amount of grain remaining. If this remaining grain is eaten by another cow all control over the system is lost. To determine how much each cow must eat, the farmer has a system which enables him to compare milk production with a specific amount of feed per cow. Other factors involved here are the quality and amount of forage available, price of grain, and the type of cow and her stage of lactation.

One unit in this system consists of stalls which will accommodate the feeding of fifteen to twenty cows, depending on the level of their milk production which determines the feeding time for each individual cow. It is anticipated that when this system is available on the market it will save considerable labor time. That will most assuredly feed the wishes of many overworked dairymen. ●

WE WON'T START THE REVOLUTION WITHOUT YOU

The theme for the 1976 UIUC Engineering Open House will be "Revolutions in Engineering." The annual open house presents student projects, industrial displays, and demonstrations of engineering process and scientific principles. This year it will be presented Friday, March 5, 1976, from 10:00 a.m. to 8:00 p.m., and Saturday, March 6, 1976, from 9:00 a.m. to 4:00 p.m.

If you would like additional information please contact Engineering Open House, 300 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●



The unusual pattern displayed on the left is a computer-generated hologram produced by UIUC researchers in the Department of Electrical Engineering. To the right is a photograph of the image the holograph produces when a beam of coherent light penetrates through it. These were produced as part of a project to obtain images of inaccessible objects.

SEEING IS BELIEVING

Everyone has heard the proverb, "It's not what you say that counts, it's what you don't say." Researchers at the University of Illinois at Urbana-Champaign have also heard it, but they have decided to change the proverb just slightly. To them, "It's not always what you see that counts, it's what you don't see." They are trying to "see" inaccessible objects through the use of holographic imaging.

Holography is an optical technique of imaging objects in three dimensions using coherent light. The process was postulated in the late 1940s, but was not demonstrated until the advent of lasers as the source of coherent light. A photograph records only the amplitude of variation. A hologram records both the phase and amplitude variation of light, so the hologram releases the full three-dimensional wave when illuminated with coherent light. Therefore, it is possible to obtain a perception of depth.

Problems arise when it is desirable to obtain an image of something that is hidden from view, such as internal body organs or underground rock formations. It is then necessary to use a holographic technique known as a compensating hologram.

Professor Preston Ransom, Department of Electrical Engineering, and graduate assistants Russell Singleton and Thomas Cutts are conducting research using compensating holograms. It may be necessary, as an example, to "see" an object concealed behind a plate of opaque or frosted glass that distorts the light wave so it is impossible to clearly distinguish the object. A hologram is made of this distorting window, and has all the characteristics of the distortion. It is then possible to take this new hologram and combine it with the window in such a way as to compensate for the distortion, and consequently, to obtain the true image.

There are many situations when light waves cannot be applied to the imaging problem. It is then necessary to use another form of radiation, such as acoustics (to put sound waves in the ground), or microwaves (for imaging through atmospheric turbulence, or in the above example of an opaque window). A form of radiation must be found that will pass through, and not be affected by, the barrier, but it must react to the object in question. Once this correct form of radiation is found, a record of the phase and amplitude radiated from the object is made. To make the recording visible, an optical wave must be created that has this same amplitude and phase variation. To do this, the amplitude and phase recording is digitized, and a computer-generated hologram is produced. Once this is drawn, a photograph is taken of it and an optical transparency is made, scaled down to the wavelength of light (from the wavelength of acoustic waves or microwaves). Therefore, the final result is the all-important hologram which is illuminated with laser light.

Another problem can often arise. If it is impossible to find a form of radiation impervious to the barrier, and it is also distorted by the medium, then digital processing must be used to compensate for this distortion. Digital processing can also enhance the image. The computer-generated hologram is then drawn, and the rest of the process is completed.

Ransom is using simulations to conduct these various research techniques. He studies equations that radiation waves would obey as they would pass through distorted media. On this basis, techniques are devised for compensating for distortions. Most of the work being done is with microwaves, optical waves, and gamma waves.

The work with holographic imaging will prove valuable for finding pieces of embedded metal or other hidden objects. It will also be possible to see things that aren't normally visible such as air bubbles in solid fuel and internal cracks or faults in a structure. This research will try to overcome all barriers to give these objects a good image. ●

NOT SOME OF OUR RESEARCH, SUM OF OUR RESEARCH

The research conducted in the College of Engineering at the University of Illinois at Urbana-Champaign for 1975 has been compiled and reported in *The Summary of Engineering Research 1975* which has recently been published. This annual publication describes the many projects conducted in the departments and laboratories of the college, and the Department of Computer Science in the Graduate College.

The *Summary* includes project descriptions, names of sponsors and investigators, and an extensive listing of UIUC publications.

Copies of the *Summary* are available at no charge to students and faculty of UIUC and for a one dollar handling charge to persons outside the University. Copies may be obtained from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

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COLLEGE OF ENGINEERING
VOL 17, NO. 7, FEBRUARY 1976

inside outlook:

LOCALIZED CORROSION CONTROL
USING SIMPLE CAMERAS IN PHOTOGRAMMETRY
LEAD DEPOSITION ON LEAVES
WASHINGTON AWARD GOES TO RALPH PECK
ZERO MAINTENANCE PAVEMENTS

PIT STOP

It is almost impossible to hear it happening, and it's very difficult to see. If it's felt, it's probably too late. Yet this process is constantly occurring everywhere and has an economic cost of $15 billion per year. No, it's not the rise of consumer prices. This very expensive and often serious problem is corrosion.

Corrosion is the unwanted destruction of metal by the oxidation process. Dry corrosion occurs at high temperatures, without the presence of liquids. Wet corrosion occurs when oxidation takes place at any temperature in the presence of a liquid electrolyte, such as salt water. Another form of corrosion is mechanical shearing (or fretting) of a surface. An example of this is the action between gears that aren't properly lubricated. A large number of specialty materials (like chromium or nickel) are currently in use to combat a corrosive environment. But these are in short supply; for the time being they can be used to reduce corrosion, but they can't be obtained indefinitely. Another alternative is being explored by Professor Richard Alkire of the Department of Chemical Engineering at the University of Illinois at Urbana-Champaign. Alkire is studying methods to avoid corrosion by using better engineering systems and designs, instead of using special materials.

Localized corrosion occurs when pits form in highly corrosive metal. These pits penetrate the metal and form a crack which will result in the eventual failure of the structure. General or uniform corrosion takes place when an entire surface corrodes. Both of these types of corrosion contribute to the huge dollar losses, but since there is more knowledge about uniform corrosion, Alkire's research concerns the localized variety.

There are three problem areas involving pit and crevice formation in localized corrosion. How is the pit initiated and how does the crevice begin to form? Once the pit is initiated, how does it grow and what causes it to stop growing? Investigations are being conducted with mass transfer and potential distribution phenomena in controlling the growth rate of these pits and the conditions under which they will stop growing. If the pit can be made to stop growing while it is still small, the resultant losses in the metal will have also been contained. The last point involves the methodology in designing good experiments on pitting or crevicing.

Normal corrosion proceeds at a very slow pace, so researchers prefer conducting accelerated tests using electrical power supplies to speed the corrosion process. But there can be circumstances where the use of the power supply causes a basic change in the corrosion process. Since the point of Alkire's research is to relate to the real world, the experiments he conducts with accelerated corrosion must be carefully designed to make sure that he is examining the same type of corrosion that occurs naturally.

To study this corrosion process Alkire is using a theoretical approach. On the basis of limited experiments, mathematical models of different aspects of the corrosion process are constructed. These models consist of equations that have a mathematical solution (one type of equation might describe the surrounding atmosphere), and these equations are combined to describe more complex behavior. The various models are then used to predict what can't be measured experimentally.

There are three applications for this approach. First, it is possible to find what effects control the corrosion phenomena so the engineer can design a system to avoid these effects. Mathematical models will indicate under what conditions one phenomenon is more important than another. Second, mathematical models will provide some notion of the validity of scale-up, or accelerated testing. This is necessary because experiments conducted in the laboratory must have relevance in a real situation.

And third, experiments of an artificial nature must be designed so that factors irrelevant to the situation don't interfere with desired results.

When measured results are obtained, it is necessary to know all the processes that have led to them. Alkire's research also has an experimental program where models are tested against artificial and real-life corrosion systems.

All structural metals are unstable and tend to corrode spontaneously, so research on localized corrosion control will contribute a great deal to prevention of monetary losses and will aid in the designing of structures containing corrosive metal. This work will fill all the crevices of missing information that will eventually halt corrosion. ●

A MAJOR FEAT IN MEASURING CLEATS

Most photographers constantly strive to upgrade their equipment by acquiring attachments that are more expensive and make their system larger and more complex. But at the University of Illinois at Urbana-Champaign, research is trying to make the best possible use of simple cameras in photogrammetry. The difference between the simple and complex photogrammetric cameras is not only due to their stability and photographic capabilities; there is a difference in cost that often approaches tens of thousands of dollars.

Photogrammetry is the widely used process of making measurements through the use of photography. In one study to determine photogrammetric uses of simple cameras, Professor H. M. Karara and V. D. Brandow of of the Department of Civil Engineering are using these cameras to obtain the orientation of cleats in coal mines. A cleat is a naturally formed fracture in the surface of the wall of a coal mine. Geologists use information concerning the position and size of these cleats to determine mine safety and the possibility of roof fall.

In photogrammetry, two photographs are taken and combined to form a three-dimensional image. Corresponding image points from each photo are used in a coordinate system to determine the exact point location in space. Combining the positions of these points results in the conception of a plane — in this case the plane is the surface of a cleat on a coal mine wall.

There is a difference in the processes of using expensive or economical photographic equipment. In both cases measurements must be made on the photograph. Calculations by a computer are used to compensate for the loss of photographic quality that is incurred by using less expensive equipment. The computer program corrects imperfections of the camera system in determining the position of points, and the result is accuracy essentially equal to that of a far more complex system. In addition to the reduction in expense, the simple cameras are less bulky and much easier to use than complex cameras, enabling the engineer or geologist to spend more time in the lab and less time subjected to the dangers of the mine shaft.

Photogrammetry has far more uses than its assistance to geologists. Other uses of photogrammetry provide contributions to topographic mapping, plans for highways or pipelines, biomedical purposes, and underwater measuring.

Continuing research will remove the mystique of photogrammetry caused by its previous expense and complex equipment. The use of simple cameras in photogrammetry may then yield results that are simply marvelous, while also convincing many other photographers to be content with the complexity of equipment they already possess. ●

TURNING OVER A NEW LEAF

Lead is one of the heavier metallic elements, but when it is dispersed in the atmosphere as a result of automobile exhaust fumes, it is as light as the air that carries and disperses it. Research in recent years has indicated that although these microscopic particles are light and difficult to detect, they are potentially harmful to plants and animals. A continuation of earlier investigations at the University of Illinois at Urbana-Champaign (see *Engineering Outlook,* January 1974) is determining how much of this atmospheric lead eventually collects on leaf surfaces, and how other atmospheric conditions play a role in the possible removal of this lead.

The research, led by Professor James J. Stukel of the Department of Civil Engineering, with the assistance of Professor F. A. Bazzaz of the Department of Botany, and graduate students D. D. Lane and R. W. Carlson, is attempting to formulate a model for measuring the amount of lead on a leaf's surface given a specific amount present in the atmosphere. The work involves experiments in a laboratory as well as in the natural environment. In the laboratory, an aerosol, tiny droplets suspended in the air, is used in a wind tunnel to disperse the lead to the leaves. To arrive at this new model, the laboratory results are compared with those obtained in the field. Other components of the model currently being explored are the effects of the various roughnesses of leaf surfaces for their holding capacity for lead, and how wash-off of the lead is affected by changes in wind and rain.

The model will ultimately be useful for investigating other toxic particulates (solid micrometer-size particles) in the atmosphere. Examples of these particulates are cadmium, solid hydrocarbons, zinc, and vanadium. This new model will disperse information concerning the dispersion of lead in the environment. ●

AN ENGINEERING OSCAR

Ralph B. Peck, professor of foundation engineering, emeritus, has been honored with the Washington Award for 1976. This award is conferred annually upon an engineer by the Western Society of Engineers during National Engineers' Week. The citation is for accomplishments which preeminently promote the happiness, comfort, and well-being of humanity. Peck received the award for eminent international leadership in, and pioneering contributions to, soil mechanics and foundation engineering practice, education and research, and distinguished service to mankind.

Professor Peck joined the civil engineering faculty in December 1942, after serving as a consultant in the design and construction of numerous engineering projects in industry. He retired in June 1974, but still holds an appointment as a visiting lecturer and research consultant with the University.

The Washington Award has been previously received by three UIUC faculty members: Arthur Newell Talbot, 1924; Nathan M. Newmark, 1969; and William Littell Everitt, 1971. They find themselves in elite company; other recipients include: Herbert Hoover, 1919; Orville Wright, 1927; Henry Ford, 1944; and Glenn Seaborg, 1965.

Professor Peck has also been the recipient of the Normal Medal, the Wellington Prize, and the 1972 National Society of Professional Engineers' Award. In 1975, he received the National Medal of Science from President Gerald Ford. ●

SAVING PAVING

Traffic congestion on heavily traveled routes is seldom looked upon with pleasure by the highway traveler, and this situation is only compounded when remedial and preventive maintenance must be performed on deteriorating or failing pavements. Although repairs on such routes are often scheduled for off-peak hours or at night, it is almost impossible to work on these highways without closing lanes and producing massive traffic jams. Lane closures and the ensuing traffic problems can clog the movement of an entire city and the cost of delays to motorists accumulates at a prodigious rate.

The solution to this problem is to spend more money during construction (10 to 30 percent more) and construct pavements that will endure. This is the objective of Professors M. I. Darter and E. J. Barenberg of the UIUC Department of Civil Engineering. They are developing design procedures for premium pavements that will require no maintenance for a period of twenty to forty years. The maintenance they are concerned with is structural; activities such as mowing, lane painting, or guardrail repair are not within the scope of their study because these do not relate to the structural adequacy of the pavement. The damage to pavements is caused by heavy traffic loads, water, salt, freezing and thawing, and the corrosion of reinforcing steel within the pavements.

Research on zero maintenance pavements began in June 1974. The first year was a field study of twenty urban areas in fifteen states. The study examined the five different types of pavements: plain jointed concrete, composite pavement (asphalt over a concrete base), continuously reinforced concrete, jointed reinforced concrete, and flexible pavement (asphalt surface over a granular material). Ten to fifteen samples of each type were studied on a total of seventy freeways. Darter and Barenberg obtained design, traffic, climatic, and material properties data and interviewed engineering personnel involved in design and construction.

The next step was an analytical study of each pavement followed by an analysis of the maintenance-free life for each of the five pavement types. For each type there were examples of good and poor performance, depending on the design. The researchers determined that the most promising type of pavement was plain jointed concrete. Their current work is focused on development of a design for this particular type of pavement.

To develop this work the researchers are conducting comprehensive analyses using the best analytical techniques available in addition to some new and innovative concepts they have developed. The general approach is to consider everything that can affect pavement performance — traffic load stress, climatic factors (temperature, moisture, freezing and thawing), foundation support, and the corrosion of steel dowel bars. The results will be a design procedure to provide pavements free of maintenance for twenty to forty years.

Maintenance and repair of freeway pavements result in the type of traffic congestion shown above. UIUC civil engineers are developing a design procedure to provide pavements free of maintenance for twenty to forty years.

Existing freeway pavements that fail can be redesigned using the new procedure, and of course, the design procedures can be used for new freeway pavements. Eventually these findings can be applied to other heavily traveled streets and roadways. The design of a zero maintenance pavement will be based on an economic justification in which the additional cost required for the original construction is balanced against the normal cost of maintenance and user delay that a conventional pavement design provides.

The final report of research findings will go to the Federal Highway Administration in Washington, D.C. It is anticipated that they will also send their recommendations to individual states as nonofficial guidelines for converting a zero into a big plus in highway maintenance. ●

PEOPLE AND PLACES

Richard S. Engelbrecht, professor of environmental engineering in the UIUC Department of Civil Engineering, has been elected vice-president of the Water Pollution Control Federation. The federation, founded in 1928, is a technical, professional organization composed of sixty-three member organizations in twenty-three countries. Engelbrecht has been chairman of its research committee since 1971. In 1966 he received the federation's Harrison Prescott Eddy Award for outstanding research.

Funds for a reading room as a memorial to the late **John B. Felmley**, a Champaign contractor, have been given to the University of Illinois at Urbana-Champaign. The gift, in addition to financing the reading room, may be used for related activities of the Department of Civil Engineering, including support for students. The room in the Civil Engineering Building will be devoted to material in the field of construction engineering and management and will be open to students, University staff, and the public and will be of special interest to contractors.

A fund to support scholarships in the UIUC Department of Civil Engineering has been established by **Walter E. Deuchler** of Aurora, an alumnus of the University. Deuchler is the founder of a firm of consulting engineers specializing in general and environmental engineering. He was graduated from the UIUC in 1910.

Ralph D. Peck of the UIUC Department of Civil Engineering was awarded honorary membership in the American Society of Civil Engineers, the society's highest honor. Peck was cited "for his outstanding career as an educator, researcher, problem solver, and communicator; for his ability to perceive a problem and to apply theoretical concepts to its practical solution; and for his innovative and inspirational instructional methods." Peck joined the UIUC faculty in 1942 and retired last year. ●

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COLLEGE OF ENGINEERING
VOL. 17, NO. 8, MARCH 1976

inside outlook:

- LEACHATE FORMATION IN SOLID WASTE
- DRAG REDUCTION IN TURBULENT LIQUID FLOW
- TWO UIUC DEVELOPMENTS ARE COMBINED FOR USE
- ENCOURAGING MINORITY ENROLLMENTS IN ENGINEERING

NO HASTE WITH SOLID WASTE

We are all consumers, and as consumers we produce varying amounts of solid waste known to many of us simply as garbage. This solid waste includes all the trash (or refuse) that leaves a household, not including items that enter the sewage system. Examples of "post-consumer" solid waste are paper, metal cans, bottles, and food wastes such as bones. In addition to households, other contributors to municipal solid waste may include commercial and government office buildings, wholesale and retail trade, and other general business and service sectors of the economy.

Even with existing and new technologies, the land is still the major repository for municipal solid waste. While some open dumps remain in use, the more acceptable method of land disposal is a properly located, designed, and operated sanitary landfill. This method involves depositing the waste in or on land, and covering it daily with a layer of soil.

There are certain areas of concern associated with sanitary landfills which may impose a hazard to the surrounding area. One of these areas is the topic of research being conducted by R. S. Engelbrecht, professor of environmental engineering in the Department of Civil Engineering, in collaboration with Michael Weber, associate professor of microbiology. The solid waste in a landfill is subject to chemical and biological decomposition with various end products being produced which, in the presence of excess moisture, may present a problem to the surrounding area. Water in the form of rainfall or runoff may enter the landfill. The buried material has a specific capacity for the adsorption and absorption of moisture, and when the capacity is exceeded a leachate is formed. Leachate is this excess liquid which forms and flows through the waste material, picking up various products of decomposition. After moving through the landfill, the leachate may reach the surrounding environment and possibly contaminate surface and groundwater resources. These resources might be the water supply for a community. It is in this regard that Professor Engelbrecht is concerned with the biological properties of leachate.

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There are a variety of sources which potentially might contribute pathogenic or infectious bacteria, viruses, or protozoa to municipal solid waste. For example, considering only the household as a source, organisms pathogenic for humans may be derived through the discard of food wastes, soiled hygienic products, various "throw-away" items, or pet wastes. These pathogens could then potentially move through the fill as part of the leachate. The potential hazard from pathogenic agents being placed in a sanitary landfill is a function of three conditions that must therefore be investigated: first, the amount and nature of the pathogens placed in the fill; second, the ability of the pathogens to survive or to retain their infectious properties in the landfill environment; and third, the ability of the pathogens to move through the landfill into the surrounding environment.

To conduct the experiments a model was constructed to simulate a core through a sanitary landfill. Researchers put 1497 kg (3300 lbs) of solid waste in a lysimeter approximately 1.5 m (5 ft) wide and 3 m (10 ft) high. Poliovirus (vaccine strain) and a reovirus were added to the waste at the time of filling the lysimeter to insure that viruses were present in this laboratory setting. Moisture in the form of water was applied to the lysimeter, and a leachate was produced and collected at the bottom. The leachate was then characterized as to its biological properties.

One very important result of these experiments is that, although a large amount of virus was placed in the lysimeter initially, viruses were never found in the final leachate. Research also indicated a steady decrease in the density of bacteria in the leachate as the process progressed with time. There are two possible explanations. There might be something restricting the movement of the viruses or bacteria through the lysimeter, or there might be an inactivating property associated with the leachate because of its chemical or physical properties.

As a next step, samples of leachates were collected from various locations around the country, and viruses and bacteria were added to them. Researchers then attempted to determine and study the inactivating properties of these different leachates. Results indicate that there is an inactivating property, but the rate and magnitude of this inactivation vary, presumably due to different chemical properties in each leachate. The properties important to the inactivating process appear to be the organic constituents, or metals such as iron or zinc in the leachate, or both, although no definite pattern has yet emerged.

The research of Engelbrecht and Weber attempts to assess the health hazard of a sanitary landfill from a biological point of view by examining leachates for the presence of infectious agents. Information to date would indicate that the biological hazard associated with sanitary landfill leachate is probably minimal, and that the chemical properties of the leachate are more important in terms of their potential impact on the environment. It's evident from this work that no time is being wasted in solving the problem of what to do with solid waste. ●

SLIPPERY WATER

Looking at the inside wall of a pipeline for a long period of time probably seems like a very boring thing to do. But, by using special electrochemical techniques to do this "viewing," UIUC researchers under the guidance of Professor Thomas J. Hanratty of the Department of Chemical Engineering can study the flow very close to a wall to obtain a better understanding of the phenomenon of drag reduction.

Drag occurs when any fluid flows past a solid boundary. But this resistance can be reduced for the turbulent flow in a pipeline by the addition of very small amounts of polymers — long chainlike molecules that are chemically inert. Present research results indicate that drag reduction is associated with a change in the structure of the turbulence close to a wall. So, Hanratty and his students are testing various polymer solutions by examining their influence on this turbulent structure.

Their research procedure involves the placement of electrochemical probes flush with the wall of a pipe (so they don't interfere with the flow). These probes provide information on the amount of fluid moving past the probe, and the flow patterns next to a solid boundary. The electrodes are at various locations on the wall so it is possible to study simultaneously the fluctuating flow at all of these locations and gain a better picture of the turbulent flow.

Drag-reducing polymers have a number of possible applications. Pipelines would not have to be designed for a peak load because it will be possible to increase their throughput by adding polymers. Drag reduction could minimize the friction of ships as they pass through water by injecting the correct polymer along the ship's hull. It will also be easier to bring oil through hoses from ships to the shoreline. Drag-reducing polymers could not only reduce the frictional losses in fire hoses, but also give a more compact jet of water. The use of these polymers in firefighting equipment is currently being tested.

There are some disadvantages to the use of polymers. These substances tend to deteriorate over a period of time, so they must be constantly replenished, therefore increasing the cost. Degradation of polymers also makes it difficult to use them in long pipelines, since they would have to be constantly reinjected into the pipeline.

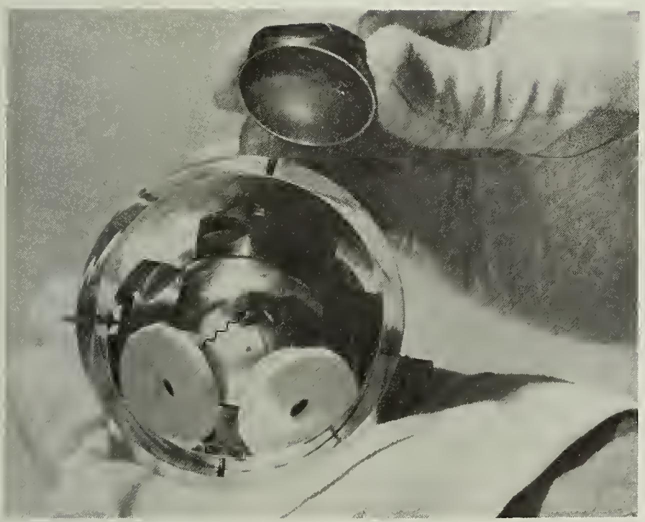
However, drag reduction will undoubtedly increase the efficiency and practicality of some types of fluid transport equipment. And, despite the added cost, research findings such as these will not slip through anyone's fingers. ●

A USEFUL COMBINATION

Over a period of years numerous inventions are proposed and developed on a campus as large as the University of Illinois at Urbana-Champaign. But it is often true that as these years pass we lose sight of how these inventions are expanded upon and how they continue to make contributions to science and industry. For this reason it is interesting to examine two advances made in similar areas at UIUC and see how they are currently being successfully combined for use.

The electrostatic gyroscope and the plasma display panel are being used together for navigational purposes on the Trident submarines. The gyroscope is important in the submarine navigation system, and the plasma panel displays the derived navigational data. It is then possible for the crew of the submarine to read, interpret, and use this information. The navigational information generated by the gyroscope makes it also directly applicable as a navigation system for civil aeronautics and maritime transportation.

The major problem with most gyroscopes is keeping the rotor contained in it from being disturbed by the friction



This photograph shows the ball contained in an electrostatic gyroscope, invented at the University of Illinois at Urbana-Champaign. This ball is suspended in a vacuum and is used for navigational purposes, as in the Trident submarines.

from its bearings or from air movements. But the electrostatic gyroscope is a free, two-axis gyro that employs a spherical metal rotor shielded from stray magnetic fields and supported without physical contact in an ultrahigh vacuum by high-voltage electric fields.

The concept of the electrostatically supported gyroscope was first proposed in 1952 by Professor A. Nordsieck of the University of Illinois Control Systems Laboratory (now the Coordinated Science Laboratory). Initial attempts to develop an electrostatic gyroscope elsewhere were unsuccessful. But in 1957, the development was undertaken in the UIUC Coordinated Science Laboratory by a group under the direction of Howard Knoebel, research professor in the Coordinated Science Laboratory and professor of aeronautical and astronautical engineering and of general engineering. The basic research was completed in 1962 and further development was continued by individual industrial companies.

The electrostatic gyroscope was invented to solve the problem of navigating the first nuclear submarine. These vessels could remain submerged for months, and this new type of gyroscope did not require the submarine to surface to determine its position.

The flat panel display is a type of plasma display invented at UIUC in 1964 by Professors Donald Bitzer and Gene Slottow of the Coordinated Science Laboratory. In addition to its commercial and industrial uses, it is also widely used as part of the University's PLATO (Programmed Logic for Automatic Teaching Operations) system. The display panel's environmental and display qualities make it particularly adaptable to life aboard a submarine. The display has high brightness and contrast, along with its memory capabilities. It occupies a small amount of space, and the glass panel can withstand high temperatures. In the submarine, the panel will display navigational computer data derived from the electrostatic gyroscope and can be supplemented with visual images projected from the rear if desired.

These two University of Illinois inventions are examples of how technological developments eventually become widely used after their introduction and initial trials. This is further proof of how the engineering field does not remain static in displaying the great discoveries it makes. ●

A MAJOR PROGRAM TO ENCOURAGE MINORITY ENROLLMENTS

A program designed for 1400 minority group students in seven Chicago innercity high schools who may be potential engineers is being proposed by the University of Illinois at Urbana-Champaign. The program will be funded by the "CIC+ Midwestern Program for Minorities in Engineering" supported by the Alfred P. Sloan Foundation.

The "CIC+" program is being initiated by fourteen midwestern engineering schools as a significant new effort to motivate and prepare minority high school students for college-level engineering study. "CIC" stands for the Committee on Institutional Cooperation, the academic consortium of the Big Ten universities and the University of Chicago. The "+" indicates the participation of two non-CIC universities, the Illinois Institute of Technology and Notre Dame University. Both the Urbana-Champaign and Chicago Circle campuses of the University of Illinois are included in the program, although each will develop independent projects.

The "CIC+" program is the result of two years of discussion and planning by the engineering deans of the participating universities. They have been concerned that engineering — traditionally a profession providing upward mobility to newcomers to America and to ethnic minorities in general — has not attracted very many blacks, Hispano-Americans, and American Indians.

The seven Chicago high schools were selected for the UIUC project on the basis of both black and Latino student enrollments. According to assistant engineering dean Paul Parker, campus project director, the UIUC plan is aimed at increasing the pool of minority students eligible for engineering studies through a large-scale program in which large numbers of students will be identified and motivated. The Chicago program will, hopefully, provide a model for working with high schools in other Illinois cities. This project was based on eight years of effort by the University of Illinois to bring minority students into engineering. The goal of this program is to take less time to increase the number of minority students so that they are less of a minority. ●

PEOPLE AND PLACES

Ven Te Chow, professor of hydraulic engineering at the University of Illinois at Urbana-Champaign, has received an honorary degree of doctor of science from Andhra University, one of the largest state universities in India. He was cited for "his lifetime effort in answering the elemental need of man, the water" and for "his being truly a friend and benefactor of global humanity." He was also granted the Premier International Hydrological Endowment Lectureship Award, which required that he deliver lectures at the University of Madras, India.

Professor **Edward W. Ernst**, of the UIUC Department of Electrical Engineering, has been named a fellow of the Institute of Electrical and Electronics Engineers for his contributions to improved methods of laboratory instruction. Ernst developed college laboratory work which challenges students and gives them the excitement of discovery and freedom of self-instruction. He is the twenty-third person on the UIUC electrical engineering faculty to receive this honor.

Professor **Y. K. Lin**, of the UIUC Department of Aeronautical and Astronautical Engineering, has been awarded a senior visiting fellowship for the summer of 1976 by the British Science Research Council. Lin was chosen because of his research in the application of probability theory to structural dynamics problems. He will visit the Institute of Sound and Vibration Research at the University of Southampton, England.

Professor **M. E. Van Valkenburg**, of the UIUC Department of Electrical Engineering, served as a co-chairman of a national meeting designed to increase the accuracy of studies anticipating the supply of and demand for engineers. The meeting, sponsored by the National Research Council's Board on Engineering Manpower and Education Policy, was attended by several hundred persons from governmental manpower offices and professional societies.

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inside outlook:

PHASE TRANSFORMATION IN STAINLESS STEEL
APPLYING AGRICULTURAL CHEMICALS
SURFACE ACOUSTIC WAVES
ALUMNI HONOR AWARDS

GETTING TIRED OF FATIGUE

A person suffering from fatigue will usually have some indication of this problem and the need for rest to alleviate it. This rest will prevent a breakdown of the system known as the human body. Mechanical systems, however, do not operate in this fashion. Recognition of a problem is not always possible, and a resting process can be disruptive to the system and to everything that depends on it.

Professor Carl Altstetter of the UIUC Department of Metallurgy and Mining Engineering is conducting research on the fatigue process in stainless steel, an alloy composed of iron, chromium, and nickel. Fatigue occurs when a component is subjected to alternating or varying loads. Often there is no gross distortion to warn of impending failure; careful observation is necessary to find any external evidence. The component can be functioning one day and fail the next day. Fatigue failures are due to the initiation of cracks that slowly propagate as the load is repeatedly applied, until the piece finally gives way. These failures commonly occur in transportation machinery, power generation equipment, shafts for transmitting force, and in turbines and gears.

The emphasis of Altstetter's research focuses on understanding what goes on at the tip of a crack in the metal. This seems to be the key, because growth of the crack leads to deformation or damage to the component. Altstetter is searching for processes that will strengthen materials in this important region. One possible way would be to allow a phase transformation to occur ahead of the propagating crack.

Phase transformation is the change in atomic arrangement within a material, which may be made to take place when a load is applied to it. If the optimum degree of transformation occurs, the material will be strengthened, but if there is not enough or too much transformation, there will be more fatigue and the crack will move faster. A possible solution to the problem of preventing damage at the crack tip is to determine the optimum change of this atomic arrangement. One way to find this correct amount is to alter the chemical composition or heat treatment of the material in the area. Fatigue behavior or life of the tested substances is then determined by constantly applying and releasing a load. These load applications are counted until the substance fails and this count represents the material's fatigue life.

Another part of the research concerns itself with why the fatigue occurs. Microscopic techniques (electron and optical microscopes, and magnetic measurements) are used to understand the relationship between phase transformation and crack movement. Observations are made at the appearance of a crack and the degree of phase transformation that took place is then measured.

This research is finding a new solution to an old problem. The next step is making it possible to tackle new problems with a new solution. An example is in the transportation of liquified gas by ocean-going tankers. Because this gas must be kept cool, it is necessary to use materials that can withstand the high pressure of the cooled gas. A tanker ship must be built of a material that will not fatigue during pressure changes or as a result of wave action. This is one application of a type of stainless steel that can withstand high stresses and still be light for construction purposes.

Stainless steel was chosen for research on fatigue because understanding of this behavior in one substance will lead to its understanding in other widely used materials. Research results may find applications to rail or gear steel,

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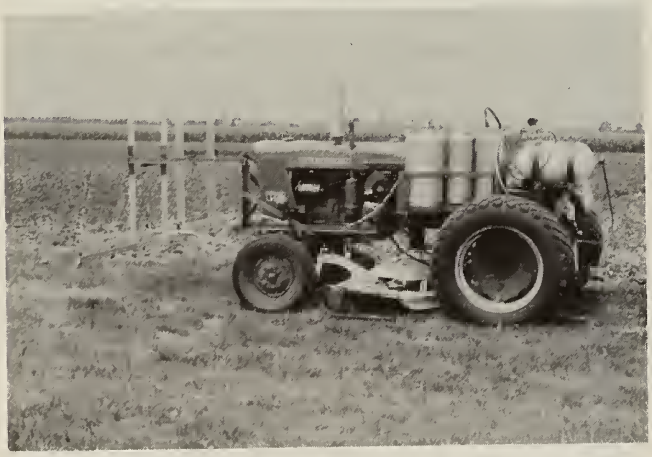
aluminum aircraft components, nickel alloy turbine blades, or other materials. When there is less fatigue in stainless steel and other metals there will be a reduction in the maintenance costs and an increase in the reliability and safety of components that may otherwise malfunction or fail completely. There will finally be a solution to the tiring old problem of fatigue. ●

GET THE DRIFT?

Using an aerosol or other type of sprayer usually does not involve much waste. The can of deodorant might miss its target temporarily, but the situation is easily corrected. This lack of spray efficiency is minimal because both the applicator and the desired amount of sprayed material are small. But when the spraying involves the application of agricultural chemicals over wide expanses of land, the possible subsequent wastes can become quite costly and sometimes dangerous. This is the reason for studies measuring spray drift by Professors B. J. Butler and L. E. Bode of the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign.

Any fine droplet produced by a nozzle can be moved off target by the wind. Such movement is called spray drift, and the research involves comparing different factors that might reduce this drift. Examples are various spray nozzle types, use of lower spray pressure on the nozzles, operating the sprayers at lower heights, or the use of spray thickeners to increase the viscosity of the pesticide mixture and hence the drop size produced by the nozzle. The optimum combination of these factors can provide valuable knowledge and consequently improve application procedures.

The experimental procedure involves assembling a weather station to determine all the climatic factors and using a dual boom spraying technique. The boom sprayers are alike except for the factor that is being tested. The pesticide solution is applied through both sprayers at the same time with a different fluorescent dye added to each solution. The spray drift deposits downwind at various distances on plastic target sheets. The sheets are then washed and the wash solution analyzed to see how much of each dye (and therefore, of the chemical) is present. This amount of dye is an indicator of how much of the chemical has drifted away various distances from the sprayer. A typical experiment would compare two nozzle types. The experiment is done in the field, and all weather conditions — wind, moisture, barometric pressure, temperature difference at different heights — are measured before and during the testing procedure. A computer is used to provide exact numerical results on amounts of drifting, and eventually it should help to indicate trends under specific conditions.



The ground sprayer shown above is used for dual application of agricultural chemicals. This dual technique is necessary in order to compare how two different factors can affect the drift of these chemicals when they are applied. The research is being conducted by the UIUC Department of Agricultural Engineering.

Farmers have known that different nozzle types give different spray drops and drift potential, but these experiments will enable spray applicators to put definite numbers on these quantities. This research informs farmers of the most efficient way to apply the chemicals. The experiments also pretest new techniques before they are used in the field. On occasion a commercial product will even be tested for its possible individual benefits. The results verify predictions and provide exact measurements. They are important because of the dangers that exist when sprayed chemicals don't land where they should, damaging both man and the environment, and due to the increased costs caused by this kind of inefficiency. Hopefully these new findings will drift into the right hands and apply to a wide variety of farming situations. ●

THE WAVE OF THE FUTURE

Everyone is familiar with the sound waves which accompany a television set's picture. But a less widely known form of sound energy, surface acoustic waves, is being studied to improve the performance of televisions or other electronic equipment. Televisions are one of the many applications for surface acoustic waves. Surface acoustic wave technology was originally designed to provide the functions of tuning and channel selectivity previously achieved by complex electrical circuits. Further investigations are being conducted by Professor Bill J. Hunsinger of the UIUC Department of Electrical Engineering and the Coordinated Science Laboratory.

Surface acoustic waves are acoustic energy that propagates along the surface of a solid, similar to waves along the ocean. Since they move along a surface they are accessible for detection and manipulation. When the waves propagate along a piezoelectric material (a material that responds to mechanical pressure with an electrical signal, and vice versa) they carry an electric charge that can be detected by conductors on the surface. It is easy to change the characteristics of a device by changing the pattern of conductor lines on the surface material.

The filter in a television receiver which allows a viewer to watch one channel at a time typically requires about twenty-five components and fifteen adjustments during its manufacture to achieve good selectivity. Since there are so many adjustments they can easily go out of tune during use, posing frustrating problems to the television set owner.

The same selectivity function is accomplished by incorporating into the set a new type of filter that uses surface acoustic waves. The device converts an electrical signal to acoustic energy, performs the filtering on this acoustic propagation path, and then converts this acoustic energy back to an electrical signal. The difference between the two types of filtering systems is that the first system only uses electric signals while the second introduces acoustics. The second system also eliminates the components and adjustments that have made the typical filtering device so complex.

This new filter using surface acoustic waves performs its functions by converting the signal which contains all channels to an acoustic beam. A transducer on its surface detects the waves propagating underneath it and picks up only those waves with the proper length while ignoring the rest. The small device is simple, easy to manufacture, reliable (it won't go out of adjustment), and inexpensive when compared to the cost of other filters.

Hunsinger's research involves improving the performance of surface acoustic waves, improving design techniques that use these waves, and expanding the applications of this type of device to other systems. Experiments in improving the selectivity of the filter are attempting to increase the ability to build up the signal desired, relative to the amount all the other channels are suppressed. Thus far, the research has devised new measuring techniques to study the characteristics of surface acoustic waves, and the structure of the transducer has been improved.

At the present time development of the filtering device using surface acoustic waves is at the prototype stage. A few thousand devices have been placed in television sets, but as of yet, the device is not being commercially sold. Undoubtedly, when the use of surface acoustic waves in television sets is perfected, many television manufacturers and purchasers will wish to tune in on these improvements. The result will be a SAW (surface acoustic wave) playing an integral part of what you see on television. ●

ACCOLADES FOR ENGINEERING ALUMNI

Seven alumni of the UIUC College of Engineering who have distinguished themselves with outstanding careers in industry, education, and the military have been recognized with the Alumni Honor Award at the college's twelfth annual awards convocation. This award, established in 1965, recognizes alumni who have distinguished themselves by outstanding leadership in planning and direction of engineering work, by fostering the professional development of young engineers, or by their contribution to knowledge in the field of engineering.

The award recipients are: Clifford M. Andrews (president, Ferro Corporation, B.S. ceramic engineering 1934), Robert B. Dillaway (deputy for laboratories, U.S. Army Material Command, M.S. physics 1951, Ph.D. mechanical engineering 1953), Richard B. Engdahl (senior project leader, Battelle Columbus Laboratories, M.S. mechanical engineering 1938), Harvey R. Fraser (dean of academic affairs, Oregon Institute of Technology; president emeritus South Dakota School of Mines and Technology, Ph.D. theoretical and applied mechanics 1956), Dan H. Pletta (professor emeritus, Virginia Polytechnic Institute, B.S. civil engineering 1927), Emilio Rosenblueth (professor, Instituto de Ingenieria, National University of Mexico, M.S. civil engineering 1949, Ph.D. civil engineering 1951), and Brigadier General Frederick A. Smith, Jr. (dean of the academic board, U.S. Military Academy, Ph.D. theoretical and applied mechanics 1968).

The College of Engineering is proud to present these awards as a means of bringing attention to the achievements of these distinguished alumni. ●

RESPECTED ENGINEERING EDUCATOR DIES

The oldest faculty member of the UIUC College of Engineering has passed away. Ellery B. Paine was 100 years old. He joined the University of Illinois faculty in 1907, became head of the Department of Electrical Engineering in 1913, and retired in 1944.

One of the men Paine brought to the Illinois faculty was the late Professor Joseph T. Tykociner who invented sound-on-film movies. In the first public demonstration on June 9, 1922, at the University, Paine was the first man to appear on talking film. He recited Lincoln's "Gettysburg Address," because he could think of no words of his own to say to a camera.

Paine had a lifelong interest in students and electrical engineering graduates. As a tribute to him on his 100th birthday, the UIUC Electrical Engineering Alumni Association established the Ellery B. Paine Fund for Faculty Development. ●

PEOPLE AND PLACES

Professor **Andrew W. Granato** of the UIUC Department of Physics has been honored with the Senior U.S. Scientist Award in recognition of his accomplishments in research and teaching. The award entitles him to continue his work at a research institute in the Federal Republic of Germany.

Professor **Shee-Mang Yen** of the Coordinated Science Laboratory and the Department of Aeronautical and Astronautical Engineering has been invited by the U.S.S.R. Academy of Sciences to visit the Soviet Union. He will visit various institutions and laboratories throughout the country and give lectures on numerical methods for solving rarefied and continuum gas dynamics problems.

Ven Te Chow, professor in the UIUC Department of Civil Engineering, has been awarded an honorary degree of Doctor of Engineering by Yeungnam University in Daegu, Korea. This was the first honorary degree ever conferred to a civil engineer in the history of that country; previously such degrees have been awarded almost entirely to social scientists. Chow was cited for his outstanding contribution to the advancement of scholarship and to the culture of mankind.

Professor **Wilbert F. Stoecker** of the UIUC Department of Mechanical and Industrial Engineering has given the keynote address at a meeting of the Australian Institute of Refrigeration, Air Conditioning, and Heating in Melbourne. Stoecker also presented a technical paper before the group and conferred with engineers at the Commonwealth Scientific and Industrial Research Organization in Melbourne.

Martha E. Williams, professor of library administration in the Coordinated Science Laboratory of the University of Illinois, has been invited to serve on the Neurological Diseases and Stroke Science Information Program Advisory Committee. Williams will serve as a consultant to the National Institutes of Health for a four-year period.

The first recipient of the newly founded Nadai Award is Professor **George M. Sinclair** of the Department of Theoretical and Applied Mechanics. This annual award from the American Society of Mechanical Engineers provides recognition of distinguished contributions to the research, development, and applications of materials. The citation recognizes Sinclair's contributions to our knowledge of the fatigue and fracture of metals, of mechanical testing, and of failure analysis.

Professor **Charles P. Slichter** of the UIUC Department of Physics was nominated by President Gerald Ford to fill a term on the board of National Science Foundation. The term expires in May 1978. ●

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inside outlook:

A SEISMIC HISTORY OF ILLINOIS
BICYCLES AS URBAN TRANSPORTATION VEHICLES
PROFESSORS ELECTED TO NATIONAL ENGINEERING ACADEMY
RESEARCH TO FIND NEW USES FOR IRON OXIDE
STRESSES AND CRACKS IN GRAIN BINS

SEISING UP ILLINOIS

When one thinks of the history of a state, important people or political events come to mind. But in this instance that would be incorrect. Two engineers at the University of Illinois at Urbana-Champaign have compiled a history of major earthquakes that occurred in the state of Illinois since approximately 1800. Professor W. J. Hall of the Department of Civil Engineering and his research assistant C. J. Montgomery are the first to compile these data for Illinois and the immediate surrounding areas.

Most people do not associate earthquake danger with Illinois, but this is not very wise. Some very strong earthquakes have occurred in or near the state in the past 200 years. Between December 1811 and February 1812 there were three severe quakes centered around New Madrid, Missouri. These were felt in an area covering two million square miles. And as recently as November 1968 there was an earthquake in south central Illinois felt over a 580,000 square mile area. These are a few examples of the many earthquakes that have occurred almost annually in the area and why Illinois should not be considered safe from their effects.

A history of this kind is helpful to engineers in a number of ways. Until this report was compiled there was no complete and current summary of seismic events in Illinois and in the surrounding areas which affect the state. The history will also be helpful to the building industry because some plans for buildings must include seismic design — the building will be constructed to resist a certain amount of earthquake motion. Data of the type in this seismic history are used by geophysicists to draw earthquake hazard maps. When city building codes are written these maps can be combined with engineering judgment and theory to arrive at force levels to which buildings in an area should be designed. Since only a few communities in the midwest presently have building codes which incorporate seismic provisions, this study can help make the public aware of exactly where earthquakes have occurred in the past. This report is also serving to aid the seismology activities committee of the Structural Engineers Association of Illinois. Hall is chairman of this committee.

To compile the history, data were gathered from past publications and other histories that were previously assembled for the area in and around Illinois. These include U.S. government earthquake listings, summaries of earthquake histories of Missouri, Ohio, Kansas, and Arkansas, and information from the *Bulletin of the Seismological Society of America.* The researchers attempted to keep and use the information thought to be relevant for engineering purposes, such as time, location, and a measure of the size of the earthquake. The report, which lists 335 earthquakes, does not include all the earthquakes which have occurred in the area — a minimum intensity must have been exceeded. For example, an earthquake must at least have had the following characteristics: during the day it was felt indoors by many, outdoors by few; at night, some people were awakened; dishes, windows, and doors were disturbed; walls made a creaking sound; and standing cars were rocked noticeably.

Engineers will be able to use this information as another base to confirm the judgment that the elements of their designs are correct. The report will be helpful to engineers and others interested in specific geographic areas and their history. Truly this is one engineering report with earth shattering implications. ●

EASIER RIDERS

No one can question that most people could use a little more physical exercise, and the increasing energy crisis is doing its share in making everyone use their own energy, instead of taking it out of the environment. Bicycling is one way to cope with our energy squeeze and get exercise at the same time, and this form of transportation has great potential if it is used properly. That is the reasoning behind the current research of Professor L. Daniel Metz of the Department of General Engineering at the University of Illinois at Urbana-Champaign. He is investigating the use of the bicycle as a primary urban transportation vehicle.

Three kinds of research are being undertaken. It is first necessary to look for the power required in cycling. There are energy losses that occur during bicycling — rolling resistance of the tires, some bearing drag from the wheels, and aerodynamic drag. In a continuation of previous work, calculations are made as to the amount of energy consumed by each of these factors. These calculations are important because the faster a person is riding, the more important these factors become, especially aerodynamic drag. Results will indicate how much power must be continually supplied by the rider to maintain a speed.

As a second element of his research, Metz is attempting to determine the amount of power a person riding a bicycle can exert over an indefinite, continuous length of time. If research indicates that it takes 3000 watts to maintain a reasonable speed, this may be impossible for a human, and so the practicality of cycling as transportation is in question. Metz is trying to define an "average" individual and the amount of power this person can reasonably generate. Much of this ergonomics research is in the literature, though often not in directly usable form.

The third aspect of the research focuses on removing a portion of this power-generation problem from the cyclist's legs. Methods are being sought to provide energy assists for bicyclists which would increase their time and distance capabilities. One concept is to use small auxiliary motors attached to the wheels of bicycles; a second is the use of riding tunnels which would provide a continuous tailwind, thereby assisting in speeding the cyclist on his way.

Cycling benefits the rider as well as the environment. It is an aerobic exercise, providing rhythmic, constant, and uniform pressure on the human cardiovascular system. If the bicycle replaces the automobile as an urban transportation vehicle, there will be a subsequent reduction in the pollution problems caused by auto exhausts in major urban centers and a general increase in the physical fitness of the rider, although the energy savings in terms of the national energy budget would be small. So, with the increased information about bicycling and with increased bicycle usage, for more reasons than one we'll all breathe a little easier. ●

ACADEMICIANS

The National Academy of Engineering has elected Professors Alfredo H-S. Ang and Richard S. Engelbrecht, both from the UIUC Department of Civil Engineering, as new members. This is the highest distinction which can be conferred upon an American engineer, and the two bring to eighteen the number from the University who have received this honor.

Ang was selected for his development of "practical and effective methods of risk reliability approaches to engineering safety-and-design structural criteria formulation." He is currently working under a half-million dollar grant from the U.S. Department of Transportation to develop forecasts of safety in air, rail, and highway transportation systems. Ang has been a member of the UIUC faculty since 1959.

Engelbrecht was elected to the academy for his "leadership in environmental engineering through education and health-related research." He is vice-president of the Water Pollution Federation and has been chairman of the federation's research committee since 1971. Engelbrecht joined the University's faculty in 1954.

The academy, established in 1964, elects to membership and honors engineers who have made important contributions to engineering theory and practice or who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology. It advises the federal government, upon request, in matters of science and engineering, sponsors engineering programs aimed at meeting national needs, encourages engineering research, and recognizes distinguished engineers. ●

DON'T THROW IT OUT

Iron oxide is currently discarded as landfill, but it may prove to be a valuable natural resource. The Pfizer, Inc. plant in East St. Louis, Illinois, which produces 100 tons of this waste daily, has awarded a research grant to the University of Illinois at Urbana-Champaign to uncover potential agricultural or commercial uses for this material. The nontoxic waste consists largely of iron and gypsum with 70 percent moisture. The sludge comes from the production of iron oxide pigments for the paint, magnetics, and electronics industries.

The research at UIUC will be as diversified as the possible solutions. Professor Carl S. Larson, assistant dean of the College of Engineering, is coordinating research in cooperation with the Departments of Ceramic Engineering, Agronomy, and Forestry.

The possibilities of using the material in ceramics and refractories are being explored by Professors Arthur L. Friedberg and Sherman D. Brown of the Department of Ceramic Engineering. Professor Thomas Hinesly, agronomist, is investigating the possibility that the iron-rich material may benefit iron-deficient soils of lawns, grasslands, and forest areas. Professor Charles Walters, Department of Forestry, is investigating the possibility that the material may be used as a fire-retardant with a special type of hardboard developed by UIUC researchers working on the use of other types of waste products.

This is quite a lot of research for a great deal of wasted iron oxide. With future developments, the problem of finding a use for this waste product will be ironed out. ●

STRESS AND GRAIN

Ah, the stresses we must encounter in everyday life. They can really make things difficult. But people are not the only ones subject to stress. Grain bins, the large containers used to protect and store grains, are subjected to various stresses and cracks due to their contents and the surrounding environment. The problems of these bins are being studied by UIUC engineers in the Department of Theoretical and Applied Mechanics.

In these very large bins, the solid grain applies a pressure to the walls of the bin that is similar to that produced by a liquid such as water or oil. But the pressure a bulk solid applies is more complicated; it varies with time and depends on the flow patterns that develop within the bin.

The grain in this bin was subjected to the moisture of a flooding river. The grain swelled so much that it eventually burst the bin that was holding it. The design of grain bins able to withstand this type of stress is the topic of research in the UIUC Department of Theoretical and Applied Mechanics.

Friction, which occurs as the grain slides along the walls, affects the loading on the walls. Pressure can also result from an increase in the moisture content of the grain. Heat can make the grain swell; low temperatures will make it contract. Wind can also exert pressure on the bin. The intensity of the wind and its direction are variable, causing an uneven pressure around the walls.

Any or all of these forces combined can lead to failure. Cracks can form on the walls as was the case in bins near the Mississippi River Valley when the river flooded. Water seeped in, the grain became soaked, exerted pressure, and the bins failed. Because they are constructed of thin sheets of galvanized iron, wind pressure can cause empty bins to buckle. Stresses due to bending are produced in the bin walls because of the unsymmetrical nature of the wind load around the outside of the bin. Most of the bins designed and in use today do not take this bending action into account. It was this problem that led the UIUC researchers to design a bin that can withstand all of these pressures.

To arrive at a solution, graduate student Sukhvarsh Jerath, with the guidance of Professors Arthur Boresi and Henry Langhaar, is building a mathematical model of a cylindrical grain bin topped with a conical roof. The model involves the numerical solution of a large number of equations (200 or more) for a large number of unknown variables. Key features of the model are equations that consider the continuity at the edge where the cylindrical walls meet the conical roof.

The results of the model indicate the amount of stress and displacement at different locations in the bin. From these, it is possible to determine appropriate thicknesses and to discover critical areas in the bin which deserve special design consideration. Another feature of the model will be used to determine how a crack will propagate through a bin once it occurs.

Solving these problems may prevent further damage to the bins. The research can also lead to solutions that can be applied to any tank that stores solids, as in those containing coal or iron ore for industrial use. The results will also reduce stresses in engineers because no longer will grain bins become has beens. ●

CURRENTLY BATTING AT .875

Seven out of eight would be an exceptional hitting streak for a baseball batter, but a team of undergraduate designers from the UIUC Department of General Engineering has posted a similar mark in a more academic competition. For the seventh time in the past eight years, a team of undergraduate general engineering students has won an award in the Engineering Student Design Competition of the Lincoln Arc Welding Foundation.

Robert Burns, Perry Hendrickson, and David Olson received a fourth-place award for their design of a buried-piping building anchor. Their faculty sponsors for the project were Professors Morris Scheinman and Tom Conry.

The award is accompanied by a cash prize of $250. Although not as large as fabled baseball bonuses, it is a definite indication that Burns, Hendrickson, and Olson are headed for the major leagues of engineering design. ●

PEOPLE AND PLACES

Professor **Ralph O. Simmons**, head of the UIUC Department of Physics, has begun a one-year term as chairman of the American Physical Society's Division of Solid State Physics (DSSP). His membership on the DSSP executive commitee will continue for another year, through April 1978. Recently, his responsibilities have included chairmanship of the DSSP program committee and membership on the program committee of the American Physical Society.

Joe E. Greene, professor of industrial engineering and metallurgical engineering, has recently been elected to the executive committee of the Thin Film Division of the American Vacuum Society. He has also been elected director of the newly formed Electron Spectroscopy Society, which is primarily devoted to the study of microchemistry of solids by Auger spectroscopy and photoelectron spectroscopy.

A six-week program to acquaint high school students with opportunities and education in engineering and related science fields will be presented June 14 through July 23 at the University of Illinois at Urbana-Champaign. This will be the fifteenth such summer program. It is supported by a grant from the National Science Foundation and forty students will take part. Professor **Jerry S. Dobrovolny**, head of the Department of General Engineering, is the director of the program.

Professor **Roger A. Strehlow**, UIUC Department of Aeronautical and Astronautical Engineering, has been named to the National Research Council's Committee on Evaluation of Industrial Hazards. The committee, sponsored by the Occupational Safety and Health Administration, meets monthly in Washington, D.C., to recommend better techniques for evaluating the explosiveness of gases, vapors, and dust and to classify the relative explosiveness of compounds used in industry. ●

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inside outlook:

EXPLORING THE POTENTIAL OF FUSION REACTORS
COMPRESSIBLE CLAY IN MEXICO CITY
A NEW INFORMATION RETRIEVAL SERVICE
UIUC RESEARCH FUNDING AND GRADUATES FARING WELL

CAGING THE SUN

In recent years, a great deal of energy has been derived from nuclear reactors. These fission reactors operate by breaking apart atomic nuclei and harnessing the energy they produce. They have a number of inherent problems though. There is a possibility, however small, for a spontaneous release of radioactive material, fuel is expensive, and the waste products of the reactor are highly radioactive.

But a new source of energy, the fusion reactor, is receiving considerable attention because of its great potential. Power from fusion reactors is generated when atomic nuclei combine, or fuse. The process is identical to the one occurring in the sun. However, there are many problems in constructing a fusion reactor that must be overcome before this new form of energy can be produced in large quantities. One of these problems is a current topic of research in the Department of Metallurgy and Mining Engineering at the University of Illinois at Urbana-Champaign.

Fusion takes place with the nuclear fuel in the form of a plasma, an ionized gaseous nuclear "soup." For most fusion designs, this plasma is composed of hydrogen isotopes of deuterium and tritium. Because the reaction of these crashing atoms must occur in extremely high temperatures, the substances are difficult to contain. The problem is not unlike someone offering you a small piece of the sun. What do you keep it in?

Currently the job is being done by magnetic confinement; the plasma is being held in place by a "bottle" of magnetic fields. The method is satisfactory, but an enclosure is still necessary to keep the plasma from the surrounding area. The proper enclosure will have great demands made upon it. Not only must it remain strong at extremely high temperatures, the first enclosure wall will be constantly bombarded by the neutrons produced in the fusion reaction, a process known as radiation damage. Because of these and other conditions, this first wall must be made of a refractory metal, one with a high melting point. Only a few of these metals are available in sufficiently large quantities, are cheap enough to make their use practical, and have all the qualities enabling them to be used for construction purposes. These necessary characteristics have narrowed the choices to two refractory metals, molybdenum and niobium. These are used alone or in a combination to comprise the first enclosure wall.

Not all of the designs for fusion reactors have plasma burning at all times. In a design called theta-pinch, the plasma is introduced intermittently, it reacts, the residue is removed, and new plasma is introduced. Because temperatures are constantly going up and down, stresses on the metal are consequently increasing and decreasing. This cyclic stress causes fatigue, or cracks, that can propagate and spread through the enclosure wall. Professor Ronald A. Yeske is studying these metals under stress cycling and slow deformation (creep) at the elevated temperatures of a fusion reaction.

Yeske's work involves trying to simulate the conditions that would exist at the first wall of a fusion reactor, except for the radiation damage. He is looking for a characterization of the response of refractory metals under periodic removal and application of stress at this wall. An experimental facility was constructed that combined high temperatures in a high vacuum atmosphere. The observations that result from this work will provide valuable preliminary information for the construction of fusion reactors in the future. In other words, when the first reactors are built, some very important questions will already have been answered.

This preparation is especially important because of the valuable qualities fusion reactors could exhibit. Unlike fission reactors, there is virtually no possibility for the spontaneous release of dangerous radioactive waste. The worst that can happen is that the "fire" goes out. There is plenty of fuel available for fusion reactors. Deuterium is available in great quantities from the sea and tritium can be bred by using molten lithium as a coolant. Radioactive waste is not a by-product of fusion reactors; they create helium, a harmless gas. This new type of reactor may provide a clean, inexpensive way to produce energy, without being dangerous. One drawback of the fusion reactor is that the entire reactor becomes radioactive and it is too hot for people to be around while it is operating. A more serious problem is that the reactor has not yet been proven as a reactor possibility, i.e., as of now, it takes more power to get fusion to occur than the fusion process itself will produce.

Fusion reactors might someday become a major source of energy and fuel. Before that occurs the diffusion of information concerning refractory metals and their place in fusion reactors will have been most valuable. ●

DOWN MEXICO WEIGHS

Nearly every major metropolitan area in the world faces unsettling problems. Mexico City is an exception; its problem is settling. Three-quarters of the area of Mexico City — the third largest city in North America — rests on a highly compressible clay that is slowly sinking under the weight of the city. A four-year study conducted at UIUC has found out why.

Certain sections of Mexico City have settled as much as 8 m (26 ft) since 1900. This settling, called subsidence, which is induced by the extraction of water from deep wells, has created a number of problems. Casings of old water wells that were formerly underground are now sticking out of the ground because the area around them has settled. Steps must be added to an historical monument built on a deep foundation because the surrounding area is sinking. Buildings on shallower foundations sink more rapidly, making it necessary to walk down to reach them.

New construction is difficult under these conditions. Structures built on shallow foundations settle due to the weight of the building. New construction can also pull down adjacent buildings, causing cracks when one settles more than the other. Buildings constructed on a deep foundation settle more slowly; but they will stick out from their more rapidly settling surrounding neighbors. The subsidence also causes a down-drag force by the soil on the foundation of the buildings. Underground structures also suffer. Subsidence causes sewer mains to rupture, underground cables to snap, and tunnels to collapse.

For the past thirty years, engineers from Europe, Mexico, and the United States have extensively studied this soil. One particular type of clay mineral was blamed for the exceptionally high compressibility. Four years ago, research at UIUC on this particular material was begun by Professor G. Mesri, Department of Civil Engineering, and Dr. B. F. Bohor, Illinois State Geological Survey, to determine exactly why it has these particular properties.

Samples of this clay, aptly termed Mexico City clay, were brought to Illinois, and various engineering and composition studies were conducted. Mesri and Bohor found that a major portion of this clay is composed of diatoms (microscopic algae) or microfossils (skeletons or skeletal fragments). Sixty-five to seventy-five percent of the dry weight of the clay is composed of porous diatoms, and this is the major source of its unusual behavior. The water-filled diatom particles make up the open framework of the Mexico City clay, causing the soil to act like a pile of sponges.

The presence of the diatoms in the soil results from a set of geologic circumstances peculiar to Mexico City. The area was originally a lake in a valley. Roughly ten thousand years ago, volcanoes dumped large amounts of ash on the area. This ash is silica, an environment favorable to the prolific growth of diatoms. The result is a soil that is composed of cavities capable of holding a great deal of water; nine parts out of ten of this volume

This photograph shows the microscopic fossil structures that comprise what is called Mexico City clay. The behavior of this unusual clay is being studied in the UIUC Department of Civil Engineering.

are water. There are other components of the soil including clay minerals and organic matter that contribute to this quality, but the diatoms play the major role in the soil's compressibility.

The Illinois research to clearly define the composition and behavior of the clay was conducted with scanning electron microscopy, x-ray diffraction, and chemical analysis, as well as measurements of the soil's physical properties. Although this investigation has provided a better understanding of the behavior of Mexico City clay, it still does not prevent any of the problems. But understanding is important in itself as the first step in settling the problem once and for all. ●

LET YOUR FINGERS DO THE RUNNING

It is always great to have information at your fingertips. Now it is also possible to have large amounts of valuable data just by using your fingertips to make requests from a computer system. This is made possible through the Information Retrieval Research Laboratory (IRRL), a research unit within the UIUC's Coordinated Science Laboratory.

This new information retrieval service provided by IRRL is available at a small fee for use by anyone in the University as well as local business establishments. The search is well worth this small cost because it is much faster than manually searching through the literally millions of references to technical literature that are available. As one example of the forty-five on-line data bases, the *Science Citation Index* provides more than 410,000 new references a year. All together, there are more than 20 million references to articles, papers, books, reports, conferences, and proceedings that are searched by IRRL. It would be virtually impossible for anyone to search these manually.

Under the direction of Professor Martha E. Williams, IRRL has developed and acquired the necessary equipment to support the retrieval of research references by using computer systems, special computer languages, and various data bases. Search services are coordinated by information scientist Sandra H. Rouse. Because the intent of the laboratory is to provide the basics for research in a real-world atmosphere, real data bases are used. These bases provide coverage corresponding to nearly all the major abstracting and indexing services, and there is at least one appropriate to almost every department of the University.

Tapes of reference information, which are the heart of the system, are created by data-base producers such as the Engineering Index, Inc. or the Institute of Electrical Engineers (IEE, a British professional organization). Users can search as far back as data have been entered, or look for information as current as the bi-weekly or monthly update that most data bases provide.

A major portion of the data-base service involves the use of on-line systems. An on-line search, unlike a batch search, provides an immediate response to the user. The principal on-line systems and data bases used by IRRL are maintained at Lockheed Aircraft Corporation and the Systems Development Corporation, both located in California. Communication networks are used to gain access to the two systems that, although they provide similar services, use different command languages. The various data bases provide the user with reference source information much like a library card catalogue, but in far greater detail and with a far greater number of references. The user can obtain a copy of the information needed directly from the television-like terminal during the search, or the system can provide an off-line printout which is then mailed to the searcher.

Between the two on-line service vendors, users have access to forty-five different data bases, including the Engineering Index (COMPENDEX), the IEE data bases (INSPEC), and abstracts of metals, meteorology, physics, electrical engineering and electronics, and government report announcements. Some of the on-line files even contain statistical data and routines so that a user can manipulate provided data with that already on file, allowing the system to do all the work.

With the added capabilities of this new form of information retrieval, and with the improved speed it provides, the service not only gives users a long arm to reach reference data bases, but also literally lets your fingers do the running. ●

MONEY MATTERS

One of the measures of a great college is how much support it attracts; another is how well its graduates perform in the marketplace after leaving school. By both measures, the UIUC College of Engineering is in good shape. The total research funds budgeted for engineering research and engineering-related research outside the college in fiscal 1975 were the second highest in the nation, and two recent studies of the salaries of engineering graduates reported record highs.

The March issue of *Engineering Education,* published by the American Society for Engineering Education, ranks UIUC as second in the nation in terms of separately budgeted engineering research and engineering research conducted by units outside the college with a total of $24,720,000 in expenditures. Although UIUC was only one of 195 engineering colleges and six engineering and technical affiliates reporting, UIUC alone accounted for nearly 6.5 percent of the total research expenditures nationwide. More than $20,697,000 (82 percent) of the UIUC total came from the federal government, private nonprofit organizations, or business or industry.

Graduates of the UIUC College of Engineering are also doing well. Beginning salaries of students who graduated at midyear average $1,113 per month, the highest average in the college's history. The average monthly salary earned by the new engineers has increased by $444 a month over the past ten years and by $691 in the last twenty years.

Experienced alumni engineers are doing equally well. Those who graduated ten years ago report an average increase of 193 percent above their starting salaries. Graduates of five years past have increased their salaries by a healthy 69 percent margin above their starting pay. ●

PEOPLE AND PLACES

A UIUC alumnus, now senior manager for the trans-Alaska pipeline, has been named the construction industry's "Man of the Year." **Frank P. Moolin, Jr.**, graduate of the Department of Civil Engineering in 1956, was cited by the *Engineering News-Record* for his "strong leadership which helped boost productivity on the trans-Alaska pipeline, the nation's largest private construction project."

The Guillemin-Caver Award of the Institute of Electronical and Electronics Engineers was awarded to Professor **Timothy N. Trick** of the UIUC Department of Electrical Engineering and Coordinated Science Laboratory, and to two of Trick's former students, **Thomas J. Aprille, Jr.**, and **F. Robert Colon.** The award, for the best paper published in the past year in the institute's *Transactions on Circuits and Systems,* was for a report on research contributions to the analysis of communication circuits using computer techniques. The award was presented at the International Symposium on Circuits and Systems held in Munich, West Germany.

The first UIUC **Donald B. Gillies** lecturer will be Professor **Alan J. Perlis** of Yale University. He will be at the University of Illinois at Urbana-Champaign in September to give a series of lectures and to work with students and faculty. The lectureship was endowed in 1975 by gifts from colleagues, students, and friends of Gillies, who died after nineteen years at the University. Perlis has been professor of computer science at Yale since 1971. Previously he was at Purdue University and Carnegie-Mellon Institute. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

COLLEGE OF ENGINEERING
VOL 18, NO. 2, SEPTEMBER 1976

inside outlook:

CHARMED PARTICLE DISCOVERED
THE SUMMARY OF ENGINEERING RESEARCH 1976
CIRCULAR ANTENNA ARRAY IN CENTRAL ILLINOIS
STUDYING EARLY MAN THROUGH ARCHAEOMETRY
DEPARTMENT JOINS THE COLLEGE OF ENGINEERING
NEW DEGREE PROGRAM RECORDS FIRST GRADUATE

CHARMED, I'M SURE

Major scientific discoveries aren't always as exciting as they are significant. However, the discovery of a new nuclear particle by a group of nineteen physicists — including eight UIUC scientists — may be "charming" as well as significant and exciting.

The reason for this particular description is that the new particle, which is similar to a proton, may be carrying the property called "charm." Working at the Fermi National Accelerator Laboratory (FERMILAB) in Batavia, Illinois, scientists discovered more than fifty examples of the new particle in a search of more than fifteen million nuclear collisions.

Twice as heavy as a proton, the particle breaks into four fragments during the experiment. One fragment has no electrical charge and the other three, known as mesons, each have an electrical charge. A few billionths of a second later, when the fragment without a charge has moved several feet at nearly the speed of light, it splits into two electrically charged particles. This special combination of five charged particles, two coming from a point several feet away from the other three, is the "signature" by which physicists identified the new particle. These events are consistent with what is termed charm.

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The new particle is described as a cousin of the proton and neutron which make up the core of the atom. The existence of its charm property was suggested by a previous discovery at FERMILAB of a new form of radioactivity. In the search for charm that followed, both FERMILAB and the Stanford Linear Accelerator Center shared in the discovery of a new meson, a "nuclear glue," now thought to be a special mixture of charm-anticharm states.

The research team worked more than five years to build the apparatus used at FERMILAB. It consists of a series of computer-coupled detector plates to analyze particles as they pass through a special magnet. The new particle itself was produced with an unusual beam of photons which were filtered through more than 30.5 m (100 ft) of liquid deuterium to remove other particles.

UIUC physicists involved in the research are Professors Gary E. Gladding, T. A. O'Halloran, Jr., and Albert Wattenberg; research associate Robert L. Mesner; and graduate research assistants John M. Bronstein, Richard N. Coleman, Maury C. Goodman, and John S. Sarracino. The team includes physicists from FERMILAB, Columbia University, and the University of Hawaii. Their work was supported by the U.S. Energy Research and Development Administration and the National Science Foundation.

Because the discovery of both this particle and its charm property is an important development in high energy physics, the group plans to continue their work. They will investigate other properties of the new particle with further experiments, hoping for equally charming discoveries in the near future. ●

OUR BESTSELLER '76

The Summary of Engineering Research 1976 is now available. Pertaining to research conducted during the calendar year 1975, the *Summary* contains a description of each of the College's more than 600 research projects as well as the names of the sponsors and investigators. An extensive listing of related literature is also provided.

Copies of the *Summary* are available free upon request from the Engineering Publications Office, 112 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

CIRCULAR ANTENNA SIGNALS SUCCESS

A giraffe cage in Illinois? That might sound somewhat strange to a casual listener. But an airplane pilot that makes frequent trips over the central area of the state would know that the giraffe cage is just one of the nicknames given to a special antenna constructed near the University of Illinois at Urbana-Champaign. Needless to say, there are no giraffes in the large circularly disposed antenna array built by the University's Department of Electrical Engineering in 1956.

This antenna complex covers an area of 16 hectares (40 acres). It consists of 120 elements that surround a vertical ground screen. These elements were placed in a circle 303 m (994 ft) in diameter. The vertical ground screen, which gives the antenna its nickname, is 20 m (65 ft) tall and forms a circle that has a diameter of 291 m (955 ft). The antenna elements receive signals and are connected to an operations building by coaxial cables. This building contains everything necessary to carry out complete operations — various terminals, receivers, and recorders. This array, which was a prototype of other antenna arrays, was designed for 4 to 16 MHz. The later arrays have widened this spectrum.

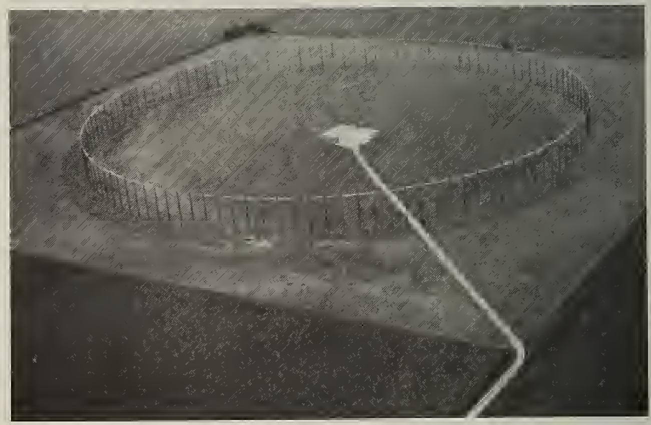
The antenna was originally built to determine the advantages that could be realized from this new form. It was also a tool for propagation research. One example is work done on around-the-world propagation comparisons. A major advantage of the antenna is that a beam can be formed from signals received from any direction. It can also receive one signal from any direction while limiting reception from other directions.

The large number of elements in the antenna and its extraordinary size make it possible to achieve a narrower beam than with other, smaller arrays. A receiver can receive only one signal at a time, but if more terminals are installed, more signals can be received simultaneously. If the diameter of the antenna were to be increased, it would be possible to get a better beam and improved reception. But it has not been believed that the gains would justify the added expense.

At the present time there is no commercial use for the antenna. The armed forces have found the array to be useful for its intended function of radio direction finding (determining the direction from which a signal is arriving) and they are beginning to realize the array's usefulness for receiving high-frequency communications signals. A very important use of the antenna is this ability to locate a signal as well as receive it.

Current research by Professors Edward Ernst and John Dyson and their colleagues, of the Department of Electrical Engineering, involves looking at the problems of using the antenna array for general communication reception as well as direction finding or catching signals that otherwise might not have been picked up. An example of these uses for the antenna is the reception of signals from ship to shore. In this instance it is desirable to receive a message and then forward it to the right party, making the communication applications of the antenna very useful. Interference presents the major difficulties and it is beneficial to exclude as much as possible of this interference from the signal to be received.

Research with the antenna will hopefully find new and unlimited applications for this excellent communications tool. Progress with the circularly disposed antenna array will move straight ahead, never going around in circles. ●



This aerial photograph of UIUC's circularly disposed antenna array has earned the nickname "giraffe cage" due to its 20m (65 ft) vertical ground screen. The antenna is used for investigations of circular arrays and propagations studies by the Department of Electrical Engineering.

ARCHAEOMETRY DIGS A LITTLE DEEPER

Programs of engineering research have contributed a great deal to their particular areas of study. But occasionally, applications of this research can be made to areas somewhat removed from the primary interest. At the University of Illinois at Urbana-Champaign, a professor of ceramic engineering is continuing his work with new materials for electrical application while using techniques and findings of this work for new studies in archaeometry.

Archaeometry is concerned with the physical and chemical analysis of archaeological materials. The technological experience and facilities available at a large university can make great contributions to the field. Because of the interest in the technologies that produced archaeological materials, which include ceramics (and glass) and metals, contributions from an engineering viewpoint are useful.

Professor David A. Payne, of the Department of Ceramic Engineering, is studying both thin and polished sections of ceramic materials with an eye toward their use in sophisticated electrical applications. The materials are examined microscopically to determine how they were made, the degree of heat treatment involved, their internal structural arrangement, and relationships between their structure and the properties of the material.

Recently, this ceramic microscopy work was also applied to archaeological materials. In collaboration with Professor Thomas J. Riley of the Department of Anthropology, and others, a seminar series was begun to identify problems in archaeometry.

A new area of study such as archaeometry involves many questions that must be answered. If early societies were so primitive, how did man obtain the temperatures to cast and work metals? What materials were used to make ceramics, and how were these materials used? In one example of research, artifacts from different sites are studied to determine commercial trading patterns and cultural migrations. Was the ceramic made from materials indigenous to the area in which it was found, or was it brought in from a distant area? Firing methods are explored by techniques of contemporary ceramic engineering, the color of the ceramic is examined for identifying trace impurities. Often, examination of the texture of a material might reveal how it was originally made.

Most of Payne's work involves microstructure analysis. The composition of an artifact can often be determined by examining its phase structure. It is possible to see changes in technology that reflect changes in society over a period of years by examining a series of materials from a particular site or culture. Microhardness measurements are used to characterize coatings, glazes, and phase distributions within materials. There is even field work done around the work to obtain samples of these classical materials. In obsidian (volcanic glass used long ago for tools), dating is accomplished by examining the diffusion of water, and site-determining impurities are identified by neutron activation analysis.

The procedures used for contemporary ceramics research have resulted in sophisticated techniques for materials characterization and have had engineering applications for new materials. Now these modern methods are also making contributions to the archaeological study of previous civilizations. The professional interactions between the engineer and the archaeologist provide applications of science to archaeology that yield valuable and unique information. Eventually, research that uses today's ceramic technology should reveal the basic foundation of that technology in years and societies long past. ●

NEW ADDITION

The College of Engineering at the University of Illinois at Urbana-Champaign welcomes a new addition to its academic family with the start of the 1976 fall semester. The Department of Computer Science, formerly part of the Graduate College, has become a department of the College of Engineering.

This change caps a twenty-seven year growth period for the department which began in 1949 when an informal group of faculty members interested in the relatively new field of digital computers formed the Digital Computer Laboratory. They followed the advice of Princeton mathematician John von Neumann and constructed their own computer rather than purchasing a model being developed by a commercial firm. The UIUC group built two systems, the ORDVAC for the U.S. Army and ILLIAC I for the University. ILLIAC I was the first in a series of four highly innovative computers developed by the laboratory. At the time of its completion in 1974, ILLIAC IV, the final computer in the series, was the largest parallel processing computer in the world.

The laboratory was reorganized as the Department of Computer Science in 1964. From its origin, the department has worked closely with the College of Engineering in its research. As the department grew, it developed graduate and undergraduate curricula to complement its internationally renowned research programs in hardware and software. The master's degree and the doctorate in computer science were designed specifically for students with varying academic backgrounds, such as engineering. The bachelor's degree in computer science was established in 1974 within the framework of the College of Engineering.

The structural realignment of the Department of Computer Science recognizes not only the growth and reputation of the department, but also its close association with the College of Engineering. The move represents a welcome addition to the College and provides a solid foundation for continued development of computer science at UIUC. ●

LADIES FIRST

The awarding of a bachelor's degree to Patricia Eng might well be described in terms of the gentleman's maxim, "ladies first." At the close of the summer session, she became the first student to complete degree requirements in the new undergraduate nuclear engineering program.

Eng transferred to the University as a physics major from Smith College in Northampton, Massachusetts. She became interested in nuclear engineering after viewing

UIUC's nuclear reactor at Engineering Open House. When the undergraduate program opened in September 1975, she was one of the first students to transfer into it.

Her undergraduate work with reactor shielding has led her to accept a job with the Westinghouse Electric Corporation. When opportunity permits, she would like to work on an advanced degree. While UIUC offers master's and doctoral work in nuclear engineering, Eng would not be able to claim any additional "firsts" here. Since 1958, UIUC has awarded nearly 400 advanced degrees in nuclear engineering, six of them to women. ●

PEOPLE AND PLACES

Edward J. Cording, professor of civil engineering, and **Thomas D. O'Rourke,** visiting professor, both in the UIUC Department of Civil Engineering, have received the C. A. Hogentogler Award for 1976 from the American Society for Testing and Materials' (ASTM) Committee on Soil and Rock for Engineering Purposes. Cording and O'Rourke will receive the award as coauthors of a paper on soils for engineering purposes entitled, "The Measurement of Strut Loads by Means of Vibrating Wire Strain Gauges," which appeared in an ASTM publication.

Professor **Ven Te Chow** of the Department of Civil Engineering was one of three faculty members from the University of Illinois at Urbana-Champaign recently elected to the American Academy of Arts and Sciences. The academy is a national honor society with 2300 members and an active program of study and publication on major national and international problems. Chow is engaged in research and instruction in hydrology, hydraulics, and water resources engineering. He is one of seven engineers elected as new members to the academy. Professors **Robert L. Metcalf** of the Institute for Environmental Studies, and **Jack B. Harlan,** plant geneticist in the Department of Agronomy were also elected to the academy.

Professor **John E. Prussing** has been named to a half-time revolving assistant deanship in the UIUC College of Engineering for the 1976-1977 academic year. Previously, Prussing has been a member of the aeronautical and astronautical engineering faculty with teaching and research interests in the area of space mechanics. He is the eighth person to hold the revolving deanship, which was established to provide additional student and department contacts for the office of the College's associate deans. Professor **Charles E. Taylor** has been named half-time assistant dean in the College of Engineering. He will share the assistant deanship with Professor **Carl S. Larson,** who is going to half-time to resume research activities in the Department of Mechanical and Industrial Engineering. Taylor, a faculty member in the Department of Theoretical and Applied Mechanics, has pioneered in the use of lasers and holography to study three-dimensional stresses and deformation in materials. ●

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UNIVERSITY OF ILLINOIS
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COLLEGE OF ENGINEERING
VOL 18, NO 3, OCTOBER 1976

inside outlook:

INVESTIGATING WIRE CABLES AND STRESSES
COMPARATIVE ANALYSIS OF RUNOFF ESTIMATION METHODS
PROFESSOR EMERITUS JOHN BARDEEN RECEIVES HONORS
DETERMINING THE COMPOSITION OF THIN FILMS
UIUC TO HOST MAJOR GEOLOGIC CONFERENCE

THE STRESS OF THE STRAND

To millions of readers, Ann Landers counsels that knowledge about a problem is one-half the step toward solving the problem. Such advice is providing the rationale for a team of UIUC researchers concerned with the kinds and effects of stresses upon long wire cables.

Although thousands of miles of cable are used throughout the United States, a substantial portion must be replaced each year due to the weakening effects of stress resulting from use. Much on-site replacement could be reduced by proper selection of the right "rope" for a particular job. Because cable strength is determined in part by the internal placement of wires within the rope, the selection of the correct cable should be furthered by knowledge of the internal stresses in the cable.

Cable strength with respect to both selection and stresses has historically been defined by experience. For example, manufacturers have learned that a cable composed of many wires with small diameters is best for withstanding fatigue (breakage due to bending and vibration). Likewise, the damaging effects of abrasion are best alleviated by a cable which consists of fewer but thicker wires. Manufacturers also know that varying the pattern of wire strands around the core of the cable can increase the strength of the wire rope in the face of particular kinds of stress.

At the University of Illinois at Urbana-Champaign, Professors G. A. Costello and J. W. Phillips of the Department of Theoretical and Applied Mechanics are conducting an exhaustive analytical investigation of cables and stresses. The researchers are mathematically subjecting different types of cables to forces and cataloguing their responses. These findings will complement the existing guidelines based upon the experience of manufacturers. More specifically, this knowledge can contribute to the mathematical design of a cable to meet the demands of a particular application.

A basic wire cable pattern can consist of any number of strands surrounding a core. Starting here, Costello and Phillips modeled a static or fixed position situation. A pulling force or tension was applied to both ends; the unrestrained cable tended to untwist under this force. To simulate a cable in a dynamic state, they added to the cable a tension which varied with time. In reality, this analytical model is somewhat similar to the cable of a crane lifting cargo at dockside which experiences an impact. Under these conditions, the rope was subjected to strains running the length of the cable and rotation of the cable itself.

In addition, the flexibility of wire cables is being considered by Costello and Phillips. Cables whose wire strands are tightly wrapped have a small helix angle, making the rope less stiff and easier to bend. Conversely, when the helix angle is larger (visually, each wire strand of the cable resembles a spring being pulled at both ends), cables are less flexible and more stiff.

Because the design of wire cable depends on job requirements, Costello and Phillips are continuing the research, analyzing cables with more complex wire construction. In this way, the research can be useful in such diverse applications of cables as tower guylines, off-shore anchorage, elevator support, and deep shaft mining. Now that cables can be analytically designed and selected with the stresses of their particular use in mind, the researchers have taken the first steps to insure that designers and users of wire cable won't find themselves unnecessarily stranded. ●

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THE SOGGY STREETS OF SAN FRANCISCO

While television actor Karl Malden works to keep the streets of San Francisco free of crime, UIUC professors are working to keep the same streets free of rain. The topic of their research is not how to keep it from raining in San Francisco — as well as in other cities — but how to manage the rain water once it falls on the streets.

In particular, the research is concerned with the storm water runoff produced by heavy rainstorms in urban areas. Most urban sewer drainage systems in the United States can effectively carry away the precipitation excess (the rain water which remains on the ground surface) generated by a light or an average rainstorm. Systems become overburdened, however, during periods of intense rainfall. Although the problem is common in many cities, it is further aggravated in cities which are built on steep, hilly terrain, such as San Francisco. Here, the runoff collects at low points in the street, clogging street inlets and flooding the immediate area.

The inability of many urban drainage systems to handle excessive amounts of storm water can be traced to unsatisfactory methods used to compute storm water runoff and to design the storm sewer system. Devised when urban drainage systems were first being built, the early formulas were unable to reliably estimate the peak runoff volumes and flow rates generated by intense rainstorms. As a result, some costly systems were overbuilt with unrealistically large capacities; in many instances, however, peak flow rates were underestimated and systems were underbuilt. In recent years, newer methods which statistically determine storm water runoff quantities have benefitted from the availability of computer analysis, extensive weather data, and established hydrodynamic principles.

Whenever an urban drainage system floods, safety, water pollution, and environmental hazards are created. These are undesirable effects which could be controlled with better design procedures. With this goal in mind, the U.S. Environmental Protection Agency sponsored a study of the methodologies used to determine the volume and peak runoff rates of storm water. Conducted by Professors Ven Te Chow and Ben Chi Yen of the UIUC Department of Civil Engineering, the study contains a comparative analysis of early and newer runoff estimation methods and offers guidelines for their use. Its report serves as a handbook, helping engineers not only to better estimate normal and peak runoff quantities but also to design drainage systems which are tailored to the characteristics of a given urban area.

The topography of an urban area is a characteristic which has a particularly significant effect upon storm water runoff rates and the entire system design. A hilly topography offers more complex design problems than flatlands because of gravity. There is also the related problem known as "hydraulic jump," in which the water inside the storm sewer may back up, due to the steepness of the drain pipe itself. Both factors add to the complexity of the situation facing city engineers in San Francisco. Chow and Yen have investigated with them ways of catching the runoff and means to drain it. Further inputs to the study include weather data and measurements taken at various locations in the city. Specific analysis of the conditions which affect storm water runoff in San Francisco may prove beneficial to engineers faced with similar conditions in other localities.

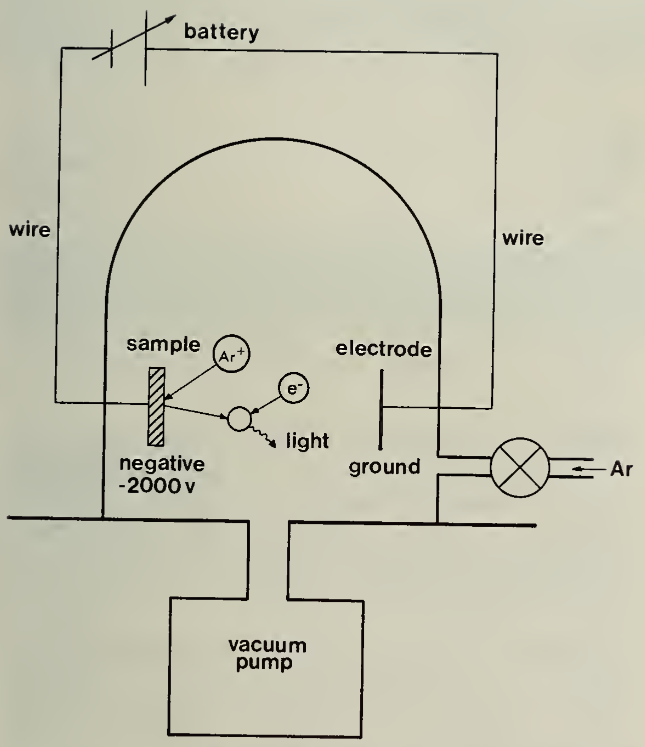
Although it is likely that many streets will continue to be flooded during heavy rains, this research provides practicing engineers with a valuable analysis. Evaluation of runoff estimation methods and establishment of guidelines for their use can help engineers to minimize this flooding problem and its related costs in the future. It can also provide the basis for a reevaluation of existing storm systems' capacities. During heavy storms, the result will be drier feet on less flooded streets in San Francisco and elsewhere. ●

BARDEEN NAMED SCIENTIST OF THE YEAR

John Bardeen, professor emeritus in the Departments of Physics and of Electrical Engineering at the University of Illinois at Urbana-Champaign, has been named the 1976 Scientist of the Year by the international science and engineering publication *Industrial Research.* The publication notes that Bardeen, although in retirement, is continuing his pioneering research in the field of superconductivity.

Bardeen is a two-time Nobel Prize winner, having the distinction of being the only man to share in the award twice for accomplishments in the same field. Bardeen won the Nobel Prize in 1956 for his key role in the development of the transistor. Subsequent work in superconductivity led to a second Nobel Prize in Physics, awarded in 1972. In addition, Bardeen was recently named to a list of the ten all-time greatest scientists and innovators in United States history.

Applications of Bardeen's work with transistors are extensive in modern life. It has resulted in a wide range of products and innovations, from reasonably priced pocket calculators to global communication systems and weather satellites. Furthermore, the potential applications of superconductivity theory in modern technology appear equally as great. To future generations, both theories will undoubtedly serve as living testimonial to the 1976 Scientist of the Year. ●



This diagram shows the vacuum chamber in which experiments are conducted on sample thin films to determine their composition. The research in the UIUC Coordinated Science Laboratory involves applying a voltage to the material in a process called sputtering. As shown here, a positive argon ion strikes the sample, causing an atom to be sputtered off. The sputtered atom is then excited by an electron and emits a characteristic glow.

RIGHT IN THE THIN OF IT

Specialized research, according to one wag, is the business of learning more and more about less and less until you know everything about nothing.

Researchers in the area of thin films can certainly share this feeling. They work daily with thin films (10 to 1000 atoms thick) on an inert base, or substrate. The exact chemical composition of these films determines their usefulness as semiconductors, light-emitting diodes, or catalytic reactors. Impurities of even a few parts in a million can have a profound effect on the properties of these films. Microchemistry, the science of finding a great deal of information from a very small amount of material, is used to determine the exact chemical composition of these films.

Through research conducted in the UIUC Coordinated Science Laboratory, Professor Joe E. Greene has developed a technique called glow discharge optical spectroscopy (mercifully shortened to GDOS) which makes this task much easier and more accurate.

A sample of the film to be analyzed is placed in a vacuum system as one electrode in a diode, and another electrode is provided. The internal pressure of the chamber is reduced by pumping, and then it is backfilled with an inert gas, such as argon. An inert gas is used because it won't react with the sample when it is introduced into the system. A high voltage is applied between the sample in the vacuum system and the other electrode to ionize the gas positively. When this voltage is applied, the sample is negative while the other electrode is at ground.

The sample to be studied has been negatively charged so the positive ions smash into the surface of the sample, stripping away a known amount of the film. This is the process called sputtering. The neutral atoms sputtered off the sample are struck by the surrounding electrons, and these atoms then give off an ultraviolet light. This light is analyzed to characterize the sample.

Each chemical element leaves its own particular "signature" in the emitted light. By measuring the wavelength of the emitted light, the element can be identified. The intensity of the light is proportional to the amount of the element present in a sample. The particular advantage of GDOS is that it is very sensitive to exceedingly small amounts of elements in a sample, and it is even possible to find concentrations and distributions of an element within the material being analyzed.

GDOS is a clear boon to any enterprise which needs to control the chemistry of a film on a substrate. Examples are semiconductor arrays, which form the heart of handheld calculators, light-emitting diodes, such as those in digital watches, and catalytic thin films, like the platinum of a catalytic reactor in an automotive exhaust system.

GDOS is also at work in the research laboratory. It is a particularly good means of studying the mechanism of sputtering itself. Another part of Greene's research involves a study of ion implantations in a material, one of the basic building techniques of semiconductors. GDOS has even been used to study radioactive atoms inside reactors, without the need to handle the radioactive sample.

Given the versatility and accuracy of the technique, it's no surprise that more and more researchers in thin films are discussing Greene's research in glowing terms. ●

GETTING TECHNICAL

The University of Illinois at Urbana-Champaign will host the technical sessions of the International Congress of Carboniferous Stratigraphy and Geology in May 1979. The sessions will follow preliminary committee meetings and the opening plenary sessions in Washington, D.C. The congress is expected to draw over 1000 scientists interested in areas of geology which include major sources of coal, oil, and gas.

The 1979 congress marks the first time that it will be held in this country. While in the United States, the attending scientists will take field trips to important coal-producing regions in the Appalachian Mountains, the midwestern states, and the far western states. Chairman of arrangements for the technical sessions is Jack A. Simon, chief of the Illinois State Geological Survey and professor of mining at UIUC. ●

PEOPLE AND PLACES

The U.S. National Committee on Tunneling Technology has named **Ralph B. Peck**, professor emeritus in the Department of Civil Engineering, as chairman of both the committee and its executive committee for the year July 1976 through June 1977. In addition, Professor **Edward J. Cording** of the Department of Civil Engineering has been appointed to a three-year term as a member of the committee.

Parviz Amirhor, who received his doctorate from the University of Illinois at Urbana-Champaign in 1974, has won national recognition for his civil engineering thesis. It was published in the *Journal of the American Water Works Association* in April 1975, and was unanimously selected for the group's annual publications award for the "most notable contribution to the science or practice of water utility development."

The Special Libraries Association award has been presented to Professor **Martha E. Williams** of the Coordinated Science Laboratory and the Graduate School of Library Science. Williams's award-winning paper appeared in the association's publication, *Special Libraries*, in 1975.

Professor Emeritus **John Bardeen**, Department of Physics, has been awarded an honorary doctor of science degree from the University of Pennsylvania.

At ceremonies held in Japan commemorating the fiftieth anniversary of the Japan Welding Society, **William H. Munse**, professor in the UIUC Department of Civil Engineering, received a Certificate of Commendation from Professor Seiichi Ando, president of the society. Munse was cited for his work which has so closely coincided with the objectives of the Japan Welding Society to develop and improve the science and technology of welding.

Joseph P. Murtha, professor in the UIUC Department of Civil Engineering, has received a Fulbright-Hays award under which he will be at the Institute for Ocean Engineering in Scotland for ten months. He will be studying the exploration, drilling, and recovery of oil and gas from under the North Sea.

Professor **S. L. Soo** of the UIUC Department of Mechanical and Industrial Engineering has been named to the United States Science Advisory Board. He will serve for one year on the environmental pollutant movement and transformation advisory committee. ●

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VOL. 18, NO. 4, NOVEMBER 1976

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inside outlook:

DYNAMICS OF A CUMULUS CLOUD
EVALUATION OF PLASTIC TUBING FOR AGRICULTURAL USE
FIRST NUCLEAR-POWERED LASER TO PRODUCE VISIBLE LIGHT DEVELOPED
NEW OFFICE AT UIUC COORDINATES TRANSPORTATION RESEARCH

BOTH SIDES NOW

What do you picture when you gaze at fluffy, billowing masses of cumulus clouds? Any child will tell you that ferocious dragons and galloping horses lurk there. But a researcher at UIUC will tell you that there is another, equally interesting side to cumulus clouds.

Professor Yoshimitsu Ogura of the Atmospheric Research Laboratory is interested in the internal picture of a cumulus cloud. Such formations indicate atmospheric conditions which are favorable for producing rain. Ogura has been studying the formation of cumulus clouds in two ways. Actual weather data have been analyzed to isolate those factors which appear to cause cumulus buildup. And mathematical models have been created in an attempt to verify through computer analysis the roles of these factors.

The probability of cumulus cloud buildup is determined by the vertical profile of the temperatures and moisture content in the atmosphere. Both factors control the extent to which a formation develops depth (visually, the height). With the right temperatures and moisture levels, a cumulus cloud can "grow" at its top. The growth is important in terms of generating rain because conditions become increasingly more favorable for rain as the cloud acquires depth.

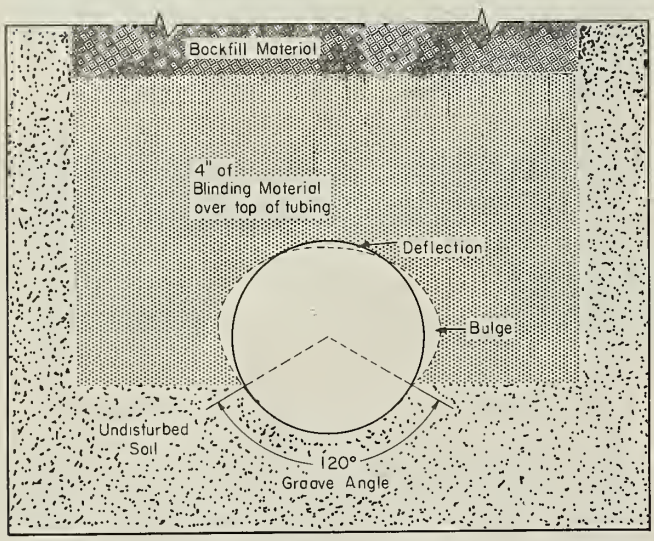
Lows in atmospheric pressure are particularly conducive to cumulus buildup. Cool air comes into contact with warm air along the fronts which accompany low pressure centers. This is the trigger which starts cumulus growth. Solar radiation during the spring and summer months can also initiate cumulus formation. By heating the ground surface, the sun warms the air close to the earth, triggering the buildup process.

In both situations, warm air rises, causing the moisture within a parcel of air to condense into droplets of water. The condensation, in turn, generates a quantity of heat which acts to push the air parcels higher. During this ascent, the water droplets become larger and larger, resulting in the cumulus cloud growing at its top as the raindrops collect there.

Although a cumulus cloud may grow to a considerable height, its raindrops may never reach the ground. Much depends on the size of the raindrops at the top of the cloud. While gravity pulls both large and small drops to the earth, the smaller drops are more affected by air friction. Consequently, they may even be carried upwards by an intervening updraft — falling "up" instead of down. Because larger drops of rain have a greater falling speed than the smaller drops, they are more likely to reach the ground surface to be observed as rain.

In addition, size is crucial because part of the raindrop may evaporate as it falls to the earth. If the drop is small, all of it may evaporate in the atmosphere between the base of the cloud and the ground surface. The raindrops that do reach the ground are the remains of larger drops.

Ogura's research indicates that the intricacies of cumulus clouds extend beyond mere appearance. In recent years, there has been considerable emphasis on generating rain by artificial means. The effectiveness of artificial rainmaking can be better evaluated and improved by an understanding of the natural rain-making process. Awareness of the phenomena that occur within cumulus formations also furthers a basic understanding of weather. It is particularly helpful in explaining the conditions which lead to hail formation. In view of the economic and scientific implications of this research, dragons and horses may merely be a secondary side to cumulus clouds. ●



Corrugated plastic tubing is being used extensively to construct agricultural subsurface drainage systems. Because plastic is a flexible material, flattening of the tubing — vertical deflection — can impede the flow of water. Research by UIUC's Department of Agricultural Engineering indicates that vertical deflection can be controlled by proper installation, particularly in the choice of blinding material and size of groove angle.

MAKING THE GOOD EARTH BETTER

To one part naturally rich soil add equal amounts of American technology and farming know-how. This "recipe" yields high agricultural productivity throughout the United States and an ability to supply much of the world with food. Research by a professor at the University of Illinois at Urbana-Champaign has been focusing on the performance aspects of a particular new "ingredient" in this agricultural recipe.

Corrugated plastic polyethylene tubing is a new material that is being used to construct agricultural subsurface drainage systems. Both clay and concrete drain tiles were used for this purpose prior to 1967, when plastic was introduced. Despite the differences in materials, the basic design of a drainage network is not affected by material choice. "Lines" are buried — usually no more than 1.5 m (5 ft) deep — and crops are planted as normal. Excess groundwater enters the lines through holes in the tubing or through gaps between tiles. The lines carry the water to larger "mains" which serve to collect and empty water from an entire field into drainage channels.

While clay and concrete materials are adequate for this purpose, plastic tubing has certain advantages. Polyethylene plastic is flexible, enabling manufacturers to prepare the tubing in coils. The material is also lighter than either clay or concrete. Both factors make the tubing easy to handle and transport. Land improvement contractors are making extensive use of corrugated plastic tubing today, particularly in the midwestern states.

Performance and durability analyses of plastic tubing are still being conducted because its use for agricultural purposes is a relatively recent development. The first study was initiated in 1971 by Professor Carroll J. W. Drablos of UIUC's Department of Agricultural Engineering. Data were collected from forty-two sites where tubing 10.16 cm (4 in.) in diameter was being used.

Although flexibility is a prime asset of plastic tubing, Drablos initially speculated that flexibility might be the cause of performance problems. When installed below the ground, plastic tubing is perfectly round. Unlike rigid clay and concrete materials, the plastic relies on the pressure of the surrounding dirt backfill to maintain its round shape. The amount of "squashing," or more precisely, the amount of deviation from its perfect shape, is termed "vertical deflection." Extensive deflection can impede and severely limit the flow of water through a line.

To unearth the entire line in order to analyze the condition of the tubing would be both costly and disruptive to crops. To facilitate the research, an instrument was developed — the deflectometer — which requires uncovering less than 1 m (3.3 ft) of line for research purposes. A portion of the deflectometer consists of a sled that has two deflection fingers attached to it. The sled and the fingers can be inserted 15 m (49 ft) into a line. As it is withdrawn, the fingers measure the vertical profile of the tubing. The measurements are transmitted by cable to a recorder which graphs the profile, indicating if any deflection has occurred. A total of 30 m (98 ft) of drain line can be evaluated from one point by inserting the deflectometer in the opposite direction in the open section.

Drablos' analysis revealed that the small-sized plastic tubing had performed well in actual use. Vertical deflection was not a major problem, but where it did occur Drablos was able to isolate the contributing factors. In particular, the analysis indicated that installation techniques had a significant effect upon the overall durability of plastic tubing.

The 1971 study provided a better understanding of the abilities of plastic tubing in terms of agricultural drainage applications. The research was especially valuable because it recommended guidelines for the use and installation of the product. The findings for small-sized tubing indicated that performance analysis of larger sizes would be equally valuable. Consequently, Drablos is continuing the research and is studying the field conditions of tubing 12.70 to 38.10 cm (5 to 15 in.) in diameter.

The introduction and successful application of a plastic material to drain American farmlands indicates the important relationship that technology enjoys with the agricultural industry in the United States. In this instance, their cooperation has resulted in making the good earth even better. ●

LIGHT EXCITEMENT

Scientists are not taking lightly a recent development in laser technology which took place at the University of Illinois at Urbana-Champaign and the Sandia Laboratory, Albuquerque, New Mexico. In fact, the personnel responsible for this development have generated a great deal of excitement over it.

The excitement centers upon the completion of the first nuclear-powered laser which produces visible light. A laser (the name stands for "light amplification by stimulated emission of radiation") operates by pumping atoms of the laser material or gas to a high level of excitement. Energy is released when the atoms return to the lower level of excitement. This is known as the "lasing" phase, in which the released energy produces a strong beam of light. Unlike ordinary light, the light waves from the laser are all in step. The light can go long distances and it can carry a great deal of energy.

The program to develop a nuclear-powered laser that produces visible light was sponsored by the U.S. Energy Research and Development Administration. It represents a cooperative effort between UIUC's Nuclear Engineering Program and Sandia Laboratory's Department of Reactor Research and Development. Research personnel consisted of Professor George H. Miley and research assistant M. Alfred Akerman of UIUC and David A. McArthur of Sandia Laboratory.

The new laser was designed and built at UIUC and taken to New Mexico. There, neutrons from the Sandia pulsed reactor were used to excite the helium and mercury vapor in the laser. Earlier tests to develop this laser had utilized the UIUC nuclear reactor to determine optimum operating conditions.

The possibility of using radiation from a nuclear reactor to power (scientists use the word "pump") a laser was first demonstrated in 1974 at the New Mexico facility. The light beam produced in this experiment was not visible; it was in the far infrared region of the spectrum. In May 1975, a UIUC research team used the University's reactor to power a laser which sent out a beam of light at wavelengths just above the visible spectrum. Using only one-third as much neutron input, this experiment produced a much higher energy wavelength of light than the earlier New Mexico experiment, and the wavelengths were in a more usable part of the spectrum. The latest development brings the laser beam all the way into the visible part of the light spectrum. In this range, the beam can be utilized by existing optical technology.

The nuclear-powered laser has certain features which make it particularly attractive to scientists. Unlike conventional lasers which are excited by large electrical power supplies, the new development uses a compact energy source. Furthermore, the nuclear-powered laser may be used in areas where conventional lasers cannot be employed. Some possible applications include isotope separation and nuclear fusion as well as other instances where high-powered, high-efficiency lasers are required.

Scientists are particularly pleased with the new laser because it may well expand the scope of laser science. As the nuclear-powered laser is tested for potential uses, it seems certain that it will continue to generate visible excitement. ●

FARM FRESH TO YOU

Have you ever stopped to think how fresh produce is brought to the marketplace from widely scattered and distant farms? Growing crops and transporting them are equally important considerations for farmers throughout the country. Recognizing this situation, a newly created office at the University of Illinois at Urbana-Champaign is investigating the transportation needs of Illinois on both a regional and local basis.

The Office of Transportation Research was established in January 1976 as a means to coordinate instructional and research resources on transportation at UIUC. The office is interdepartmental, drawing its faculty from a wide range of disciplines. Members of several departments within the College of Engineering cooperate with the Office of Transportation Research.

Since its organization, the group has been particularly concerned with the availability of ways to transport farm products to market. As an example, commodity shipments in Illinois use both railways and highways. In recent years, however, secondary roads and bridges have deteriorated throughout the state. Adding to the situation is the proposal by the federal government to abandon certain rail lines in an economy move. The Office of Transportation Research is coordinating the resources required to study the impact of changes in available methods of transporting the agricultural products of rural Illinois. It is also investigating alternatives, such as air shipment, to meet future transportation needs.

Coordination among researchers concerned with a similar problem can improve the chances of practical contributions to society as a whole. Although less than one year old, the Office of Transportation Research has taken the initiative to provide the coordination necessary to stimulate real improvements in key areas of transportation. ●

PEOPLE AND PLACES

Daniel C. Drucker, dean of the UIUC College of Engineering, has been reelected to a second four-year term as treasurer of the International Union of Theoretical and Applied Mechanics (IUTAM). Drucker, only the second U.S. officer in the thirty-year history of the IUTAM, was elected in September at the organization's General Assembly held at Delft, The Netherlands. The IUTAM is an international scientific organization, formed in 1946 to foster links between individuals and national and international organizations engaged in scientific work in the science of mechanics or related fields.

Nick Holonyak, Jr., professor of electrical engineering, has received the first Gallium Arsenide Symposium Award. He is being honored for his development of the light-emitting diode — a device which provides glowing stick-numbers used in computers and watches — and his continuing research on compound semiconductors. The award was presented at the International Symposium on Gallium Arsenide and Related Compounds held in St. Louis.

The U.S. Department of Transportation has selected Professor **Thomas D. O'Rourke** of the Department of Civil Engineering to represent the United States in an exchange program on tunneling research. O'Rourke will spend fifteen months at the Transport and Road Research Laboratory, Crowthorne, England, before returning to the University.

Professor **Frank B. Lanham**, head of the Department of Agricultural Engineering, has been installed as president of the American Society of Agricultural Engineers. Lanham took office during the society's annual meeting in June.

The Office of Coal Research and Utilization at UIUC has been redesignated as the Office of Energy Research. Under the direction of Professor **James J. Stukel**, professor of mechanical and industrial engineering, it will assume a wider role for research and development projects at UIUC relating to all phases of energy.

The 1977 Ipatieff Prize of the American Chemical Society will be awarded to Professor **Charles A. Eckert** of the Department of Chemical Engineering next March at the society's meeting in New Orleans. The prize is awarded every three years, honoring outstanding chemical work in the field of high pressure. Eckert will be cited for his contributions in the areas of molecular thermodynamics and the effects of solvents on the rates of chemical reactions.

John C. Chato, professor of mechanical engineering and bioengineering, has been appointed associate editor of the *Journal of Bioengineering*. Published by the American Society of Mechanical Engineers, the journal is a newly established quarterly series of the *Transactions ASME*. ●

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inside outlook:

DETERMINING THE TOXICITY LEVELS OF ULTRASOUND
WIND AND ROLLING RESISTANCE OF HIGHWAY VEHICLES
EFFECTS OF WATER BUBBLE SCREENS EXPLORED

DO YOU HEAR WHAT I HEAR?

The most familiar sounds in the field of medicine are usually the sounds of a patient complaining to his doctor. Existing beyond the range of human hearing (about 20,000–25,000 Hz and above) is another type of sound. To a doctor, "ultrasound" is as important as his patient's complaints.

Ultrasound is used in hospitals as a diagnostic aid when problem pregnancies are suspected. Specialists use it to conduct inutero fetal scans, providing the doctor with a visual representation of the fetus. Ultrasonic instruments can also be used to monitor fetal heartbeat. In addition, ultrasound is valuable in brain scanning and mapping procedures, and as a surgical tool. Despite its application, ultrasonic radiation has not been adequately investigated with respect to the possibility of harmful side effects. While there has never been a recorded instance of physical damage from use of ultrasound, there is a lack of suitable toxicity data. Research to generate data and to identify harmful levels has been initiated in UIUC's Department of Electrical Engineering by Professor Floyd Dunn and doctoral candidate Jack Brady under a grant from the Food and Drug Administration.

During the course of the research, several variables were manipulated at separate times. For example, two groups of pregnant mice were exposed to ultrasound at different stages of gestation. One group was exposed at day six of pregnancy, just after the embryo has been implanted on the uterine wall. The second group of mice was exposed to ultrasonic radiation at day ten of gestation, when the limb buds of the fetus were forming. This experiment generated data that were statistically analyzed to determine if any damages had occurred to either the mother or fetus. Comparisons were made among the exposed group of mice, normal mice, and control mice (mice that went through the experimental procedure but were not exposed to ultrasound). Dunn and Brady manipulated other variables in addition to gestation age. In particular, the researchers explored the effects of the intensity of ultrasonic radiation and the amount of exposure time to the radiation.

Whenever energy passes through a medium, some energy is transformed into heat. The loss is measured by an absorption coefficient and the researchers were especially interested in the absorption coefficient describing the exponential decrease in acoustic energy or ultrasound. In this experiment, a beam of ultrasound was directed at the testicles of male mice and the ovaries of female mice. Because the resulting energy loss generated heat, the researchers were also interested in any temperature-related changes in the tissue. Through experimentation, the absorption coefficient was found to be small. This may have explained, in part, the high resistance to damage in the testicles and ovaries of the mice. Following the tests, some animals were placed in a breeding situation to see if reproductive capabilities had been affected. The researchers examined the excised organs of other animals in a further attempt to locate damaging effects of ultrasonic radiation.

Animals have also been exposed to larger doses of ultrasound (far above the clinical range) to reveal the damage that might occur in the most extreme cases. At certain levels, urinary dysfunction and hind leg paralysis were noted in the mother. At a lower exposure level, but still above the current clinical range, there occurred a reduction of litter weight for some animals and a reduction in size of some fetuses.

The importance of ultrasound lies in its advantage with respect to x rays in certain situations. Ultrasound is very useful when examining soft tissues that are normally transparent to x rays. It responds to differences in density and velocity within the tissues, especially at tissue boundaries. In addition, ultrasonic radiation can be focused in ways an x ray cannot.

The advantages of ultrasonic radiation make it an important tool in hospital analysis of patients' conditions. Dunn and Brady are hoping to identify levels of toxicity for ultrasound with their research. Identification of problem areas and clarification of the effects of ultrasound will help to expand the application of this useful analytical technique. In view of its present uses and potential applications, this research appears to be a sound investment. ●

This specially instrumented automobile is being used in wind and rolling resistance tests at UIUC. A team of researchers from the Department of Mechanical and Industrial Engineering conducts coast-down tests on the interstate highways near the Urbana-Champaign campus.

TEST-DRIVING ON THE ILLINI FLATS

Although central Illinois may be as flat as Utah's famous Bonneville Salt Flats, the similarity between the two localities ends there. The research of two UIUC professors, however, could add to the comparison as their study continues to generate interest in the automobile industry.

Professors Helmut H. Korst and Robert A. White of the Department of Mechanical and Industrial Engineering at the University of Illinois at Urbana-Champaign are investigating two forces that automobiles and trucks experience on the highway. Rolling resistance is a force resulting from the "flattening" of a tire as it rolls on the highway. The deformation of the tire and the resulting resistance are dependent on several factors, particularly the weight of the vehicle, the pressure in the tire, and the construction of the tire itself. For example, rolling resistance increases as the weight of the vehicle increases. On the other hand, high pressure in the tire lessens the amount of deformation and resistance, but this efficiency occurs at the expense of passenger comfort and safety.

Wind resistance is another force exerted upon vehicles on the highway. It results from the distribution of air pressure around a vehicle as it is being driven. The amount of wind resistance is strongly dependent on the speed of the vehicle. Other factors that affect wind resistance are the overall shape of the vehicle, the shape of the vehicle's front, and air density.

Korst and White initially spent much time in the laboratory studying the mathematics of resistance. While rolling resistance increases slowly with speed, aerodynamic resistance increases by the square of the proportionate increase in speed. This means that the wind resistance at 31 km per hour (50 mph), for example, would be four times greater than the wind resistance at 15.5 km per hour (25 mph). Korst and White have constructed a mathematical model to determine the individual contributions of the two types of resistance from coast-down tests conducted with actual vehicles on the highway.

To verify the analysis experimentally, actual highway tests were conducted instead of wind tunnel simulation. This was done for several reasons. While wind tunnels and models are adequate to investigate the effects of aerodynamic resistance for aircraft, it may be less satisfactory for ground vehicles. In such simulations, it is difficult to properly account for the interaction of the ground. In addition, aerodynamic data for a ground vehicle do not approach reliability until the model is nearly half-size. Very few wind tunnels are large enough for a one-half scale model of either a truck or an automobile. Experimenting with full-size vehicles under actual highway conditions is not only more realistic but also less expensive than wind tunnel tests.

During a coast-down test, the vehicle's engine is disconnected once a specified speed is reached. For manual shift vehicles, the clutch is disengaged at this point and the vehicle coasts. Vehicles with automatic transmissions are modified by adding a special clutch in order to disconnect the engine from the drive shaft. In both instances, electronic recorders measure the slowdown rate in terms of velocity and distance. Data are collected, processed, and analyzed by computer.

Wind and rolling resistance on both a level stretch of road and a constant grade are being investigated in this study. A level site on Interstate 72 near Urbana-Champaign, and a site with a three percent grade near Marion, Illinois, are being used by the researchers with the cooperation of the Illinois Department of Transportation and the Illinois State Police. Korst and White use specially marked vehicles in the road tests. The tests take place in the early morning hours when both traffic and air movements are at a minimum.

Wind resistance and rolling resistance are important factors from both an energy and a design point of view. The researchers hope that this study can provide the basis for more realistic estimation of fuel consumption for highway vehicles. In addition, increased knowledge about the effects of resistance can influence the design of vehicles that use less fuel. Because trains also experience wind and rolling resistance, Korst and White feel that their methods could be applied there too. By experimenting "on location," the researchers continue to steadily roll along in their analysis. ●

A TOUCH OF THE BUBBLY

Just as bubbles bring soft drinks to life, they are bringing to life an intriguing research project at the University of Illinois at Urbana-Champaign. The effects and uses of bubble screens are being explored by Professor W. H. C. Maxwell and graduate student Sahim Tekeli of the Department of Civil Engineering.

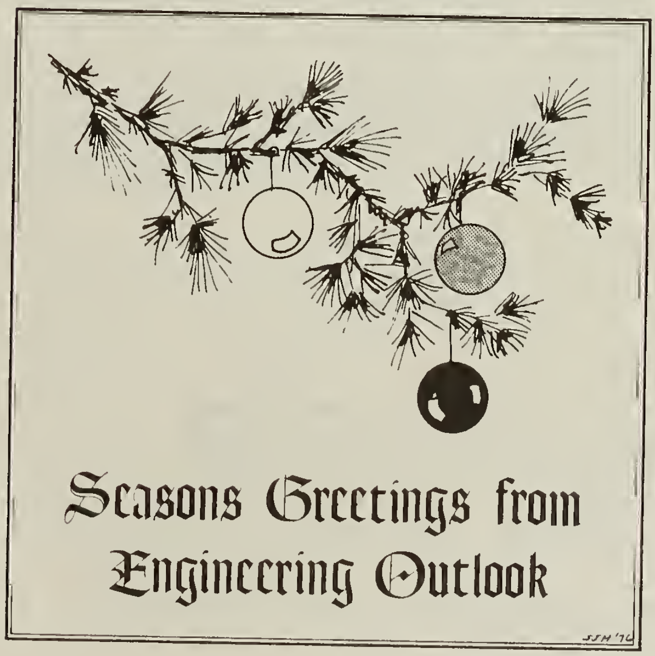
Bubble screens are useful for increasing the mixing capacity of bodies of water. The bubbles can induce a current in a lake, stream, or reservoir to break up temperature layers or to disperse liquid discharges into these waters. As they are introduced into a body of water, the bubbles rise and drag the water up with them, bringing about the mixing process.

There is a wide variety of applications for research on bubble screens. For instance, thermal power plants make hot-water discharges (the water is hot because it has been used to cool the plant's generators) into rivers, canals, and reservoirs. Because ambient water temperatures are sometimes high, bubble screens could be used temporarily to meet government standards for releasing these fluids into another body of water. In Canada, bubble screens are used in locks and canals to prevent ice formation. The flow induced by the bubbles brings warmer water closer to the surface. The bubbles can even be a temporary (they are too costly to be permanent) breakwater against ocean waves. The bubble-induced currents are directed against incoming waves to help break them up.

Because there isn't a complete understanding of how the flows of two liquid jets containing no air bubbles interact, one of the first steps in the proposed study is to investigate and characterize two submerged, simple fluid flows intersecting at right angles. In a subsequent phase of the study, Maxwell and Tekeli will explore the exact strength of the water flow generated by a bubble screen; here, a single plume of bubbles will be studied. Finally, the interaction of a jet of water and the bubble screen will be investigated.

While bubbles are very simple things to look at, they are extremely complex to study. The preliminary experiments have been conducted in a 1.2 x 1.2 x 2.4 m (4 x 4 x 8 ft) tank, complete with temperature flows. While all possible characteristics of an actual situation are represented in this small tank, there is some concern over interference caused by the relatively close walls of the tank. During the preliminary investigation, probes are placed in the water to measure the encountered air and water velocities and temperature differences. A probe sends a signal that is recorded on magnetic tape. The data are analyzed by a computer program which counts the bubbles and determines their size and velocity and the degree of mixing, in order to obtain a basic understanding of how the system operates.

A primary goal of the research will be to correlate the amount of air (the number and size of the bubbles) and the air outlet geometry (the size, shape, and spacing of the holes through which the air passes to form the bubbles) with the induced flow of water. The results of this study will provide additional information that should enhance the applicability of bubble screens. In the future, it may be possible to solve a number of stubborn engineering problems simply by adding a touch of the bubbly. ●



PEOPLE AND PLACES

The National Science Foundation has announced the award of a NATO Fellowship to Professor **Carl J. Altstetter** of the Department of Metallurgy and Mining Engineering. Thirty-six scientists in the United States received the award, enabling them to study new scientific techniques and developments in a NATO country. Beginning in January, Altstetter will study the behavior of metal surfaces in advanced energy production systems at the Max Planck Institute for Plasma Physics in Munich, West Germany.

The Water Pollution Control Federation has chosen as its president Professor **Richard S. Engelbrecht,** Department of Civil Engineering. Engelbrecht was named president-elect at the organization's forty-ninth annual meeting in October 1976. He will assume his duties in October 1977 for the organization's golden anniversary year.

Duane H. Cooper, professor of electrical engineering, is serving as the president of the Audio Engineering Society (AES) through 1976. The AES recently awarded Cooper an honorary membership for "his outstanding achievements in the advance of recording technology."

Harry H. Hilton, associate head of the UIUC Department of Aeronautical and Astronautical Engineering, has been named to the technical committee of the American Institute of Aeronautics and Astronautics (AIAA). The committee functions in an advisory capacity and provides technical assistance to various subcommittees of the AIAA.

George E. Anner, professor of electrical engineering, is a recent recipient of the Western Electric Award. Anner was recognized by the Illinois-Indiana section of the American Society for Engineering Education for his excellence in engineering education.

The American Institute of Aeronautics and Astronautics has appointed Professor **Allen I. Ormsbee** of the Department of Aeronautical and Astronautical Engineering associate editor of the *Journal of Aircraft.* Ormsbee will serve a three-year term.

Louis Pasteur University in Strasbourg, France, has awarded a Docteur Honoris Causa to UIUC Professor **Ven Te Chow.** Chow, an hydraulic engineer in the Department of Civil Engineering, was cited for his dedication and creative work in the science and technology of water. Originally the University of Strasbourg, Louis Pasteur University was renamed in 1970 in honor of the well-known chemist and microbiologist who taught there in 1849.

Professor **Wendell S. Williams** of the Department of Physics has been named a fellow of the American Physical Society. ●

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inside outlook:

THE MECHANICS OF SPORTS ACTIVITIES
1977 ENGINEERING OPEN HOUSE
EFFECTS OF ERROR ANNOUNCEMENT METHODS
INVESTIGATING MATERIAL DEFECTS IN CATALYSIS
SLICHTER NAMED TO PRESIDENT'S COMMITTEE

TENNIS ELBOW, ANYONE?

More and more Americans are enjoying the game of tennis but many also suffer a side effect known on and off the courts as "tennis elbow." In recent years, increases in cases of tennis elbow have kept pace with the growth of the sport itself. Despite the discomfort of this and other sports injuries, it should be comforting to learn that scientists are investigating the effects of sports activity upon the human body.

One aspect of the science of biomechanics concerns the study of human performance in terms of principles of applied mechanics. One goal of biomechanics researchers is to learn about the stresses and forces exerted upon the human body during an activity. At the same time, researchers seek to recommend better ways of performing in order to maximize for the participant the physiological and psychological benefits of an activity. Because much human activity involves participation in sports, biomechanics researchers have focused their efforts on the mechanics of sports activities. At the University of Illinois at Urbana-Champaign, biomechanics research is being conducted by Professor Charles J. Dillman of the Biomechanics Research Laboratory in cooperation with faculty members in the College of Engineering.

Sports activities have three basic components that interest the biomechanics researcher: technique of performance, the safety of the activity, and the sports equipment. Technique is analyzed not only to recognize ineffective ways of performing the sport, but also to determine the most effective way to perform it. It is true, however, that effective performance techniques for certain sports can be physically damaging, so biomechanics research also considers the potential risks of an activity to the body. Because equipment can affect performance technique as well as the safety of the sport, an evaluation of equipment is an integral part of biomechanics research.

One method of investigation in biomechanics is to analyze the technique of a top sports performer. At UIUC, this approach has been used to measure performance aspects of several sports including tennis, power lifting, and track and field events. A second approach to biomechanics research involves mathematical analysis of the dynamics of sports activities in terms of principles of mechanics. Analytical models of the specific system are developed and validated based upon data generated through experimental studies. The validated models provide a basis for mathematical manipulation of specific variables important to the activity. Using this approach, Dillman is currently working with Professor T. J. Lardner of the Department of Theoretical and Applied Mechanics. Dillman is conducting experiments that complement Lardner's mathematical modeling of the distribution of impact forces created by a tennis ball and racket in a player's arm.

Dillman employs a wide range of instruments to collect data on the forces and motions experienced by the human body during an activity. High-speed films are used extensively to facilitate analysis of performance technique, especially comparative analysis. A small device called an accelerometer can be placed on a limb — such as an arm for tennis — to measure the varying speeds that the limb experiences as the sport is played. When the subject performs on a force platform, the researcher is able to measure the ground reaction forces and shifting forces.

It is hardly surprising that the growing incidence of sports injuries such as tennis elbow, pitcher's shoulder, and trick knees has kept pace with the growth of participant sports in the United States. Biomechanics is attempting to remedy the situation through interdisciplinary research efforts involving physical educators and engineers. It is the hope of biomechanics researchers that as more Americans turn to sports activities in their leisure time, fewer will be turning their knees. ●

SCIENTIFIC INTEGRATION

The engineering profession has been aware of the growing need to improve conditions within the environment and society. In recent years, engineers have responded to this challenge by adopting a more broad-based approach to problem solving. Engineering today seeks to integrate both environmental and sociological factors with technical alternatives to world problems.

To emphasize this concern, "Integrating the Sciences" has been chosen as the theme of the 1977 UIUC Engineering Open House. Exhibits and displays at Engineering Open House are being designed to communicate this message to the thousands of visitors that are expected from Illinois and out-of-state. Visitors will also have the opportunity to tour the campus of UIUC's College of Engineering.

The 1977 Engineering Open House: "Integrating the Sciences" will be held on Friday, March 4, and Saturday, March 5, 1977. If you would like additional information, please contact Engineering Open House, 300 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

SCREEN TEST

Computerized bank statements and grocery receipts indicate that computer technology is being applied to many routine tasks. As a result, the importance of human-computer interaction has grown. Researchers at the University of Illinois at Urbana-Champaign have recently completed one phase of a continuing study that examines a particular effect in this area.

Humans interact directly with computers through computer terminals. Interactive terminals consist of a keyboard (similar to a typewriter) and a television-like screen. The keyboard enables the operator to enter text — either data or a program — into the computer while the screen allows the operator to read the entered text. Operators can execute a variety of tasks at interactive terminals, depending on their training. Clerical operators perform routine information filing while highly trained programmers create the programs that use the recorded data. In both instances, human-computer interaction is characterized by a two-step communication process. The first step is a mental process in which the operator generates an idea (text) in his mind or on paper. The second step is the physical process of typing which transfers the text into the computer.

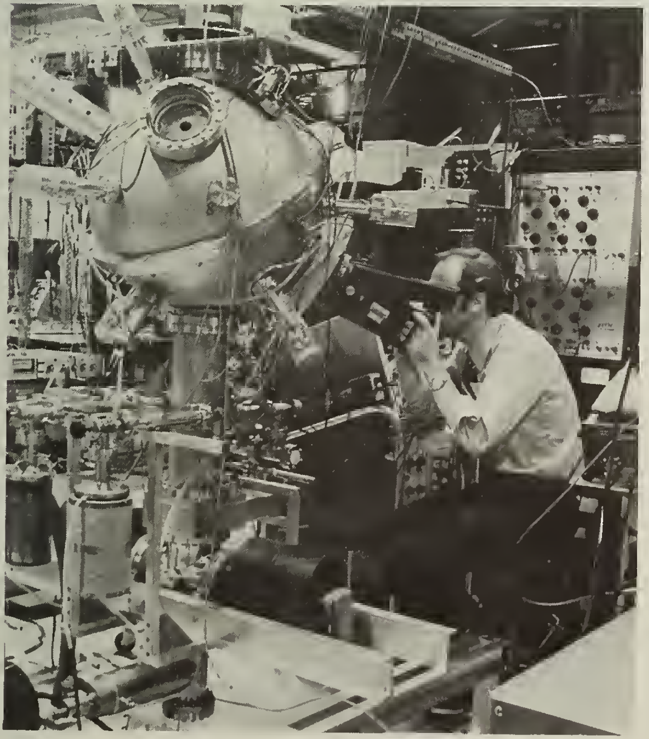
Because humans are prone to mistakes, computer systems are often designed to monitor the accuracy of the entered text. One type of error·monitoring is immediate error announcement. When a mistake is detected, the operator is immediately interrupted by the computer system. The error must be corrected before the operator can continue the task. A second type of error feedback provides an error announcement at the end of the task. In this instance, the terminal screen lists the mistakes that have been made during the actual typing process.

Professor Wilfred J. Hansen of the Department of Computer Science is interested in the effects of error announcement methods upon the operator. Hansen has hypothesized that experienced computer operators would perform better if error feedback occurred at the end of the task. Immediate error announcement would interrupt the mental step of human-computer interaction. As the operator was anticipating later steps, an interruption to correct a petty mistake would cause frustration. Consequently, the task would take longer to complete and the operator would commit more errors. In contrast, end error announcement would enable the operator to finish the task quickly. Furthermore, the operator would benefit from a release of tension upon completion of the task and would be in a more positive frame of mind to correct mistakes.

To generate data concerning the hypothesis, Hansen and graduate student Barr Segal devised a controlled experiment. The subjects were seventy UIUC freshmen and sophomores who were given simple tasks to perform at PLATO terminals. All subjects were instructed to name twenty-five of the fifty states and to list fifteen of the thirty permutations of "abcde," with "c" before "a" and "b" before "d." One-half of the subjects performed their tasks under the immediate error announcement method. The remaining subjects corrected their mistakes after the tasks had been completed.

The results of the experiment did not conclusively support Hansen's hypothesis. The immediate error announcement group did make more mistakes but they also finished the tasks faster. This may have been due, in part, to the use of trial and error by the group to complete the tasks. In addition, neither error announcement method resulted in observable operator frustration. These results raised several questions concerning the study. For example, were the assigned tasks representative of actual computer programming? Would the results be consistent with a sample of experienced terminal operators? Furthermore, were the subjects accustomed to the assigned tasks?

The goal of error announcement research is to influence the design of interaction sequences so that they maximize operator performance. While this project does not offer conclusive support of Hansen's hypothesis, it does not entirely contradict it. Rather, it suggests that additional research is the correct key for conclusive evidence. ●



Professor B. E. Cherrington is studying the plasma confined on the interior of a spherical diode. The diode can be used for confinement studies or for the irradiation of pellets by ions accelerated by the electronic space charge fields. The research project is being conducted by Cherrington and his colleagues in the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign.

DEFECTIVE GOODS

Rising prices for consumer goods have led many Americans to reconsider "slightly flawed" or otherwise defective merchandise. With a little repair work, a shirt with one short sleeve and one long sleeve can be easily made into a perfect short-sleeved shirt. Defects in materials also exist in the world of science but scientists do not always attempt to correct them. In many instances, researchers find that these defects produce interesting and useful effects.

The role of defects in solid materials has long been a research specialty of the Department of Physics at the University of Illinois at Urbana-Champaign. Currently, Professors Wendell S. Williams and A. B. Kunz, and graduate students James Bethin and David Klein, are interested in the role of material defects in catalysis.

Catalysis is a chemical process in which the rate of the chemical reaction is accelerated by some agent, often a solid material. The process is being investigated as it occurs in a fuel cell. This is an electrochemical device that converts hydrogen and oxygen into electrical energy (and water). As a source of energy, fuel cells hold much promise because they use inexpensive and plentiful fuel to create energy without pollution.

The choice of material in a fuel cell is important because its surface acts as the catalytic agent. The surface material prompts the dissociation, or breakdown, of each hydrogen molecule into two separate hydrogen atoms. The dissociation is the critical step in the oxidation (burning) of hydrogen fuel to produce an electric current. At present, fuel cells are made with platinum as the catalytic agent. Platinum, however, is a precious metal that is both rare and expensive. Because less-expensive tungsten carbide can be substituted for platinum in a fuel cell, it is being studied as a catalyst by the researchers. Tungsten carbide exhibits platinum-like catalytic properties and certain material defects in it are suspected to be important in the catalytic process.

In particular, material defects within the crystal structure of tungsten carbide may make it a good catalytic agent. The researchers are investigating specific defects known as oxygen impurities and atomic vacancies. The oxygen impurities are isolated oxygen atoms that substitute for carbon atoms while atomic vacancies are places in the molecular structure where there should be atoms but there aren't any. It is known that tungsten carbide is not a good catalytic agent without these structural defects. Furthermore, the effectiveness of tungsten carbide as a catalyst can be increased to a point by adding oxygen and creating the vacancies.

The researchers plan to study the role of tungsten carbide and similar materials in catalysis through analytical and experimental procedures. Electrochemical measurements pertinent to the catalytic process will be developed. Theoretical methods for the calculation of the bonding of hydrogen to small clusters of atoms will also be pursued. Experiments will provide a means for comparison, enabling the team to verify or to modify the analytical models. One stage of experimentation will focus on the role of defects — especially oxygen impurities and atomic vacancies — in catalysis.

A further stage of the project involves the application of the findings from this study to the area of fuel cell development. Williams and the graduate students hope to identify some general principles for making better and cheaper catalysts for fuel cells. This application holds considerable interest in light of recent energy and transportation crises. Fuel cells are a portable source of energy and could be used extensively to power urban vehicles without pollution and without petroleum-based fuels. Present lead-acid storage batteries in electrically powered vehicles, however, are heavy, operate over a short range, and must be recharged often.

The research is being administered by UIUC's Materials Research Laboratory with funds from the Energy Research Development Administration's "Project Independence" and the National Science Foundation. While the primary purpose of this study is to increase the understanding of the role of material defects in catalysis, the research team hopes to recommend materials for use in fuel cells. Potential applications of this investigation to areas of energy and transportation could have far-reaching and material effects. ●

THE D.C. CONNECTION

Charles P. Slichter, professor in the UIUC Department of Physics and Center for Advanced Study, has been named to the President's Committee on Science and Technology. Slichter and nine other members were appointed to the executive-level commission by President Gerald R. Ford. Other members of the Committee on Science and Technology include the governor of Indiana, Otis R. Bowen, and Charles H. Townes, the inventor of the laser.

The primary purpose of the committee is to conduct a two-year study of the federal government's efforts in the field of science and technology. President-elect Jimmy Carter will receive the committee's recommendations for organizational and procedural changes as well as areas in science and technology that merit increased federal support.

The recent appointment marks Slichter's return to a position on an executive science advisory committee. During the Johnson and Nixon administrations, Slichter served on the President's Science Advisory Committee. This organization was dismantled in 1972 and the current President's Committee on Science and Technology represents a bipartisan effort to reinstate an executive-level science advisory body. Slichter also serves on the governing board of the National Science Foundation.

Slichter is one of many academicians from UIUC and other institutions who serve on government committees. While the appointment is an honor in itself, it is also indicative of the reciprocal support and cooperation that exists between scientists from academic institutions and advisory agencies of the federal government. For the University of Illinois at Urbana-Champaign, Slichter is a welcomed addition to its Washington corps. ●

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inside outlook:

UIUC TEAM IN ENERGY IMPACT STUDY
SOLVING A PROBLEM IN SHIP DESIGN
METRIC CONVERSION
DEPARTMENT HEAD DIES

GOING INTO ORBES

A coordinated team approach to a problem offers a specific advantage. The varied backgrounds and individual contributions of each team member facilitate the development of a solution that is based on a broad analysis of the problem. This is the rationale for the team approach of ORBES, the Ohio River Basin Energy Study. The University of Illinois at Urbana-Champaign is participating as a team member in this research project.

Initiated in September 1976, ORBES is a one-year preliminary study whose goal is to assess the impacts of existing and proposed energy facilities in the lower Ohio River basin. The current project is the first phase of a proposed three-year assessment of the environmental, economic, and sociological effects of energy developments of all types in this region. The lower Ohio River basin is presently defined as parts of Illinois, Indiana, and Ohio, and all of Kentucky. The U.S. Environmental Protection Agency (EPA) is funding the project under the direction of the U.S. Congress.

Energy facilities such as nuclear or coal-fired power plants can have positive and negative impacts in a region. An impact operates like a chain reaction, having many possible side effects. For example, a primary effect of a power plant might be to attract more industry to an area. This effect can have an impact of its own (called a secondary impact), perhaps increasing employment or polluting the air with industrial wastes. And there are tertiary impacts, conditions that result from primary and secondary impacts. In this example, an improvement in the standard of living and an increase in respiratory ailments would be good and bad tertiary impacts.

The potentially wide scope of such impacts prompted the creation of multiple research teams to conduct the ORBES project. The goal of this approach is to obtain different perspectives to a single set of problems, helping to ensure that no major impact is overlooked. Six universities in the four states are contributing personnel to the three ORBES teams. Each group is conducting an independent assessment of the impacts of proposed and existing energy facilities in the region. To aid the analysis, academic specialists from many backgrounds — engineers, biologists, economists, lawyers, environmentalists, and psychologists, among others — can be found on the teams. ORBES is also unique because the public contributes to the project through advisory committees. In addition, the teams sponsor public meetings, enabling interested citizens to communicate their ideas about ORBES.

The University of Illinois at Urbana-Champaign is playing a substantial role in the energy assessment study. The ORBES Project Office is located here and is being directed by James J. Stukel, professor of civil engineering and of mechanical engineering and director of the Office of Energy Research, and by Boyd R. Keenan, professor of political science at the Chicago Circle campus of the University of Illinois (UICC). Stukel and Keenan are responsible for the management and coordination of the three research teams. The office will also integrate team analyses and submit a report to the Congress in summer 1977.

UIUC is also one-half of a research team that includes UICC. The group is headed by Professor Richard Klein of UIUC's Department of Mechanical and Industrial Engineering. Like the other teams, the Illinois team is independently conducting its own assessment. In addition, several UIUC faculty members have been awarded grants by the EPA to conduct special research projects on topics that supplement the ORBES study. A series of ten studies was funded by the EPA and awarded to researchers at the participating schools.

The recent controversy concerning the safety of nuclear power plants indicates a need for more information about energy facilities of all types. With the investigation of the impacts of energy facilities in the lower Ohio River basin, ORBES may generate a long-run beneficial impact of its own. ●

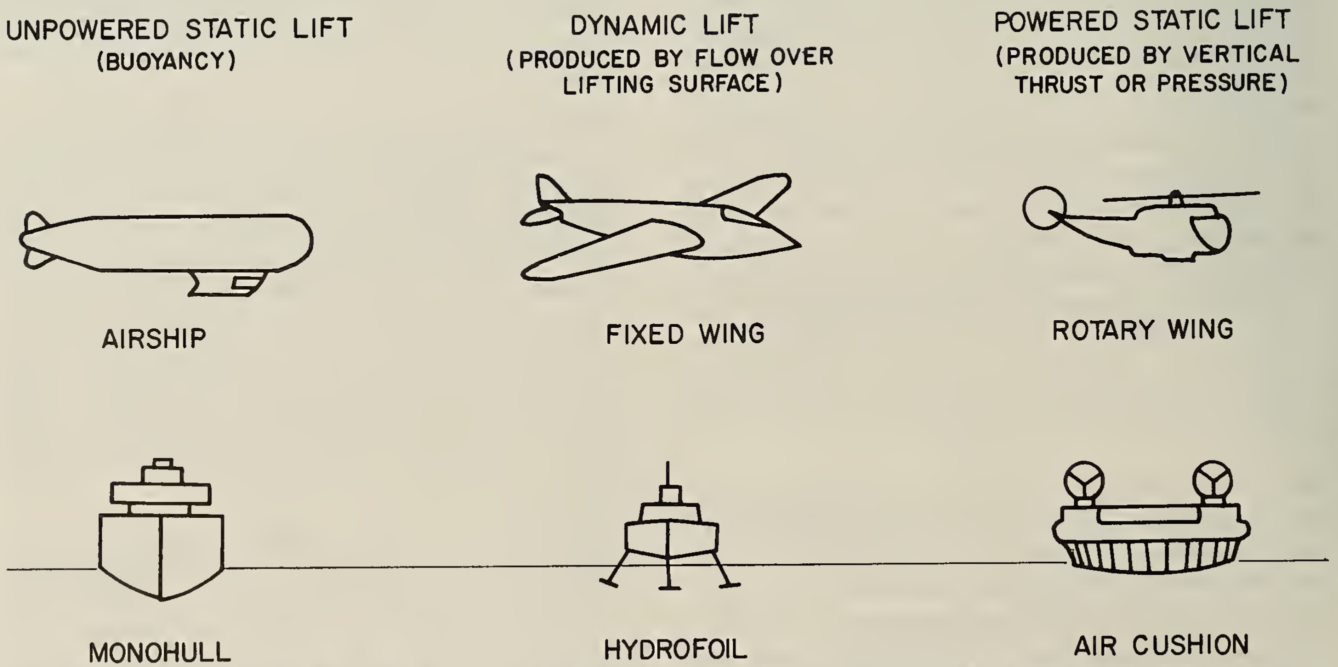
SHIPSHAPE SHIP SHAPES

The principles of shipbuilding have changed slowly since primitive man first paddled his way across the Euphrates River on a log. In contrast, aviation technology has advanced rapidly since the days of the Wright Brothers. Today, techniques in aeronautical research are being used at the University of Illinois at Urbana-Champaign to solve problems in modern ship design.

Shipbuilding has long been based on the buoyancy principle: crude dugouts and great Clipper Ships were built to float on water. Yet the movement of this type of ship is slowed by the resistance of the water. Technically, water resistance is a drag force that consists of wave resistance and friction. In recent years, design theory has emphasized less conventional forms in an effort to reduce water resistance. Both the hydrofoil and the air cushion vehicle are new developments in shipbuilding based on modern design theory. Currently, more complex shapes are being proposed to further minimize water resistance. Such designs are called hybrids because the shapes incorporate features of conventional shipbuilding as well as more recent design techniques.

While it is relatively easy to create new shapes on paper, ship designers need a way to estimate the ability of hybrid designs to reduce water resistance. Although this is a problem in naval hydrodynamics, it is being solved by Professor Shee Mang Yen of the Department of Aeronautical and Astronautical Engineering. Yen is using computer (numerical) experiments to estimate the water resistance of hybrid ship designs in a research project at UIUC's Coordinated Science Laboratory. In the past, Yen has found computer experiments to be an ideal means of studying the aerodynamic problems of aircraft design.

Although it may seem unusual for an aeronautical engineer to conduct a study in naval hydrodynamics, both fields are part of the larger discipline of fluid mechanics. Consequently, engineering similarities between the two fields are more apparent than most people would think. For example, the concept of lift is an important engineering feature in the operation of boats and aircraft. Lift is an upwards pulling force that is necessary to support the weight of the vehicle. In the design of conventional ships and dirigibles (unpowered static lift), lift results from buoyancy or floating. Both the hydrofoil and fixed wing airplane have lifting surfaces which act to create an up-



Engineering similarities between ships and aircraft are more apparent than most people would think. For example, both types of vehicles can be defined on the basis of vehicle lift. Lift is an upwards pulling force that is needed to support the weight of aircraft in air and boats in water. At UIUC, an aeronautical engineer is using his experience in aviation research to solve problems in ship design. (Illustration from *Naval Research Review*, October 1976) wards pull (dynamic lift). And, helicopters and air cushion vehicles are similar because lift is generated from a stationary position (powered static lift).

Nonetheless, the analysis of ship design and water resistance does present a unique problem to Yen. The air-water surface is a free surface which means that it can assume any shape. This characteristic of the problem makes it impossible to determine without experimentation the shape of this surface as well as the waves (and water resistance) generated by a moving ship; in contrast, airplane design does not present this problem, as it operates in only one fluid, air. Additional complications arise since the design of hybrid shapes exist only on paper.

To date, Yen has conducted computer studies of dynamic lift (hydrofoil) and powered static lift (air cushion vehicle) designs. A study of hybrid shapes is planned. It appears that a ship whose lift is produced by pressure — such as an air cushion vehicle — may be most important to the future of shipbuilding. This design reduces the contact between the solid surface of the boat and water, thereby creating less water resistance.

Yen will present a report on the computer experiments at a symposium later in the year. While the aeronautical engineer may find himself somewhat out of his usual element with this research project, his contributions may well shape the further development of modern, shipshape ships. ●

OBJECT OF CONVERSION

Mistakes in this publication (infrequent as they are) seldom go unnoticed by *Engineering Outlook* readers. Such was the case recently. In the article "Test Driving on the Illini Flats" (*Engineering Outlook* December 1976), 50 mph and 25 mph were incorrectly converted to metric units. Using proper conversion factors, the metric equivalents of these figures are 80 km per hour and 40 km per hour, respectively.

In spite of this mistake, the modern form of the metric system, the International System of Units (SI), is being introduced throughout the United States with some success. It is not unusual, for example, to see distances on interstate highways expressed in kilometers as well as miles. And most newscasts provide temperature readings in both degrees Farenheit and degrees Celsius. Yet it appears that the general public's comprehension of measurements expressed in metric units remains somewhat limited.

The metric system can be better understood if the reader associates both the metric measurement and its English equivalent with a familiar concept. Thus, 112 m (367 ft) becomes clearer when one realizes that it is the height of a giant California redwood tree. Likewise, a pressure measurement of 200 kPa (kilopascal) or the equivalent 29 psi may be meaningless to most people until it is associated with the pressure in an automobile tire.

As the United States makes the transition from the English system of measurements to the metric system, *Engineering Outlook* will continue to provide (hopefully accurate) English translations of metric measurements. It is hoped that this policy will facilitate a better understanding of the metric system among our readers. Unlike the recent conversion mistake in this publication, the metric system should not remain an object of conversation but become an accepted part of American life. ●

DEPARTMENT HEAD DIES

Henry S. Stillwell, professor and head of the Department of Aeronautical and Astronautical Engineering at the University of Illinois at Urbana-Champaign, died recently. Stillwell became the head of the newly created department in 1944 at the age of twenty-seven. Under his direction, the department expanded, attracting a faculty whose achievements and research earned the department its international reputation.

During his career, Stillwell worked to further engineering education throughout the country. He served as a consultant to many colleges and universities, helping to develop aeronautical engineering programs on their campuses. Stillwell was twice elected the chairman of the Aerospace Engineering Division of the American Society for Engineering Education.

Stillwell was fifty-nine years of age at his death. The H. S. Stillwell Memorial Fund has been established to create a scholarship in his memory. ●

PEOPLE AND PLACES

Professor **John E. Prussing** of the Department of Aeronautical and Astronautical Engineering has been appointed a member of the technical committee on astrodynamics of the American Institute of Aeronautics and Astronautics (AIAA). The astrodynamics committee submits proposals for conferences and meetings, provides assistance and technical support, and reviews technical papers for the various committees of the AIAA.

Dennis R. O'Boyle, professor in the the Department of Ceramic Engineering and the Nuclear Engineering Program, recently completed an assignment as a specialist in nuclear ceramic fuels at the Constituyentes Atomic Center in Buenos Aires, Argentina. The appointment was arranged through the International Atomic Energy Agency in Vienna, Austria. As a United Nations technical expert, O'Boyle consulted with Argentine scientists and engineers on the behavior of gaseous fission products in ceramic fuel elements.

Daniel C. Drucker, dean of the UIUC College of Engineering, recently received an honorary degree from Lehigh University, Bethlehem, Pennsylvania. The degree honors Drucker for "outstanding leadership in education and great creativity in research, especially in the theory of plasticity."

UIUC Professor **Richard S. Engelbrecht** has been appointed to the Ohio River Valley Water Sanitation Commission. Engelbrecht is a professor of environmental engineering in the Department of Civil Engineering.

The American Society for Metals has presented its most prestigious research award to Professor Emeritus **Paul Beck** of the Department of Metallurgy and Mining Engineering. Beck received the Albert Sauveur Award for research in the magnetism of alloys that he and fifteen graduate students have conducted over the past twenty years. In addition, **Charles A. Wert,** head of the Department of Metallurgy and Mining Engineering, was made a fellow of the American Society for Metals.

Professor **Y. K. Lin** of the Department of Aeronautical and Astronautical Engineering has been named a fellow of the American Academy of Mechanics.

Gregory E. Stillman and **Timothy N. Trick,** professors in the Department of Electrical Engineering, and **Suburo Muroga** and **Daniel L. Slotnick,** professors in the Department of Computer Science, have been named fellows of the Institute of Electrical and Electronics Engineers (IEEE). Their appointment brings to twenty-eight the number of IEEE fellows in the UIUC College of Engineering.

Professor **John S. Walker** was recently awarded the Pi Tau Sigma Gold Medal. The award is presented annually to an outstanding young engineering professor and is jointly sponsored by Pi Tau Sigma and the American Society of Mechanical Engineers. A member of the Department of Theoretical and Applied Mechanics, Walker was honored for his contributions to theoretical fluid mechanics. ●

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**UNIVERSITY OF ILLINOIS
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COLLEGE OF ENGINEERING
VOL. 18, NO. 8, MARCH 1977

inside outlook:

A SOLUTION FOR ANIMAL WASTE TREATMENT
ENGINEERING EXECUTIVES MEET AT UIUC
PROGRESS REPORT ON BIOMEDICAL ENGINEERING SYSTEMS TEAM
DEVELOPING A DECISION-MAKING AID FOR PILOTS

WASTE NOT, WANT NOT

Here's a riddle for you: What do an electric power generating plant, an animal feedlot, and a population of fish have in common? "Not much" might seem to be a good answer, but Professor Paul N. Walker of UIUC's Department of Agricultural Engineering would disagree with you. Walker is involved in a research project which uses all three of these seemingly unrelated items.

The first clue to the riddle can be found in an animal feedlot, an enclosed area where animals such as beef cattle and hogs are fattened before slaughter. The large number of animals in a relatively small area results in a concentration of waste material. There are several ways to handle the waste; it can be deposited in settling basins or it can be spread on fields as fertilizer. The waste can also be treated so it can be reused as feed material for a variety of organisms from algae to cattle since it is high in nutrients.

The second clue to the research riddle concerns the polycultural (many species) population of fish. While such species as the sunfish, bass, and catfish are familiar to Americans, other species such as the silver carp, tilapia, and grass carp are considered exotic by American tastes. Nonetheless, this varied population of fish can be raised as a cash crop in the United States because of the many uses for fish and fish by-products. To raise these fish on a year-round basis in Illinois, however, would require a body of warm water.

The third clue involves the power-generating plant. In addition to electricity, power plants produce a great deal of hot water. Consequently, cooling lakes are built adjacent to these facilities in which the water is stored, allowed to cool, and then reused by the power plant. Although the cooling lake serves an important function in itself, the thermal energy of the hot water is usually wasted.

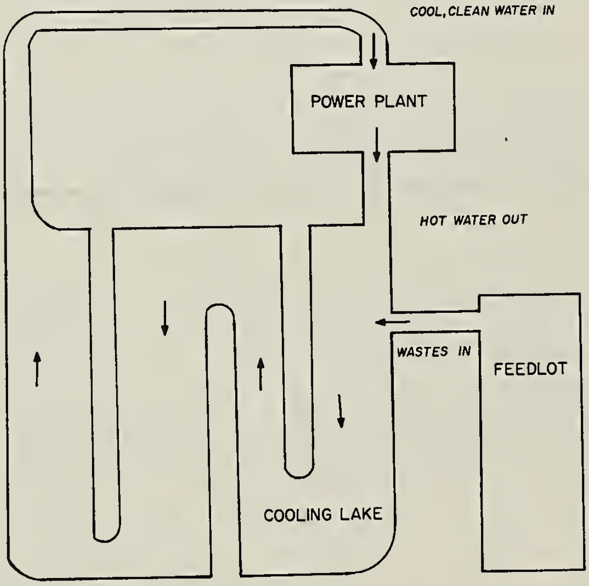
At this point, the goal of Walker's research and the solution to the riddle may be evident to you. Walker is attempting to efficiently utilize the hot water from the power plant, the nutrient-bearing wastes from the animal feedlot, and a valuable mix of fish species. Ideally, a feedlot would be located next to a power plant's cooling lake. Wastes would be added to the warm water of the lake, stimulating the growth of algae. A variety of fish could be raised on the algae in the cooling lake, purifying the water at the same time. The scheme creates, in effect, a working relationship among otherwise unrelated elements.

While the solution may now appear to be simple, there are several variables that complicate the research. Some of the variables are constant for a given power plant such as the surface area of the cooling lake. Many variables, however, are dynamic or subject to change over time such as the water temperature of the lake. Both the algae and fish are living and growing organisms, making them dynamic variables as well.

Walker is primarily concerned with the engineering aspects of the project. These involve the space and flow rate implications that result from dividing the cooling lake into sections and populating them with fish. As the hot water is pumped into the lake and mixed with animal wastes, it will be progressively cooled and cleaned when it flows through each section. From an engineering standpoint, it is necessary to determine for a given volume of water the amount of wastes which can be used and the amount of fish which can be produced. This calculation will also be affected by the difference in water temperature throughout the lake. Walker has constructed a model of this system as a means to generate further data on a complete system. The biological aspects of the project are being studied by the state's Natural History Survey.

APR 1 1 1977

The primary purpose of the research is to present a more economical and efficient way to handle the polluting nutrients from animal feedlot waste runoff. In this respect, the concept appears sound because the power company could rent the use of its cooling lake, the feedlot owner could sell animal wastes, and the fishery could sell its fish. All in all, it's a rather fishy but ingenious way to solve an important agricultural problem. ●



This diagram represents an ideal situation in which the hot water from a power plant, the wastes from the animal feedlot, and a polycultural population of fish could be utilized in an efficient and economical system. As the hot water flows through the cooling lake, it would be progressively cleaned and cooled. Research to determine the feasibility of this scheme is being conducted by Professor Paul N. Walker of UIUC's Department of Agricultural Engineering.

A FORUM FOR IDEAS

The Romans conceived of a forum as a meeting place where ideas could be exchanged for the mutual benefit of diverse groups of people. Although two thousand years have passed and the setting is decidedly different, this concept of a forum was very much in evidence last month at the University of Illinois at Urbana-Champaign.

The Illinois Alpha chapter of the national engineering honor society Tau Beta Pi and the College of Engineering invited a group of industrial administrators from the business sector to meet with them in the first College of Engineering-Tau Beta Pi Engineering Executives Forum. One purpose of the two-day event was to increase the interaction between members of the college administration and leaders in engineering-related industries. More importantly, the forum enabled the future engineers of Tau Beta Pi to meet with current engineering practitioners. And, the meeting provided the engineering executives with a view of engineering education at UIUC.

Executives from a representative sample of engineering industries and consulting firms with home offices in Illinois were invited to the Engineering Executives Forum. With Tau Beta Pi members as escorts, the fifteen executives attended classes, toured the campus, and visited departmental offices and research facilities. While the college administrators met briefly with the guests in two discussion sessions, the major emphasis of the forum was to provide the students access to the executives. In addition, the students, executives, and college administrators were addressed by University of Illinois President John E. Corbally at a banquet, and by UIUC Chancellor Jack W. Peltason and Dean Daniel C. Drucker of the College of Engineering at the closing luncheon.

It is hoped that the Engineering Executives Forum will become an annual event of Tau Beta Pi and the College of Engineering. In view of the reactions from the students, executives, and college officials, the exchange of ideas at the forum was indeed mutually beneficial. ●

THE MEN FROM B.E.S.T.

Machines are generally considered to be dependable and unerring replacements for human beings. Yet machines are merely the result of human inspiration and innovation. Furthermore, technicians are needed to maintain the operating condition of each machine. Proper maintenance of machines is particularly important in hospitals where lives depend upon the complex medical apparatus at a doctor's disposal.

Maintenance of hospital equipment is a task as complex as the equipment itself. The job can be measured by the number of machines in a hospital as each machine requires individual inspection. The task is further complicated by frequent introductions of new equipment and modifications of existing models. The cost of a preventive maintenance program is an important consideration as well. Many hospitals have neither the money nor the manpower necessary to implement a comprehensive maintenance program.

One answer to the problem emerged from a study that was initiated by Professor John C. Chato, cochairman of the Bioengineering Faculty at the University of Illinois at Urbana-Champaign. During the past two years, a Biomedical Engineering Systems Team (BEST) has been developed by Chato and the Regional Health Resource Center (RHRC) in Urbana (see January 1975 *Engineering Outlook*). Consisting of engineers and technicians, BEST now provides hospitals with engineering and other technical services, such as periodic inspection of equipment. The services are available to hospitals and clinics in east-central Illinois.

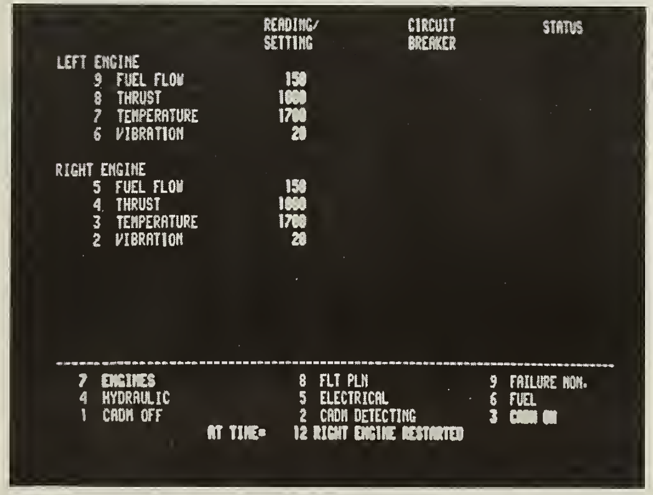
Chato's feasibility study indicated a need and a desire for technical assistance, particularly in the development of preventive maintenance programs. As developed by BEST, the goals of this program are twofold: to prevent equipment failure during actual use and to extend the useful life of expensive devices such as intensive care units (ICUs) and coronary care units (CCUs). This is accomplished by regular, periodic inspections of equipment by BEST personnel. In many instances, the team must formulate both a procedure for inspection of a particular machine and a standard for acceptable performance. In addition, BEST develops a preventive maintenance schedule for each machine, enabling the client hospital to use its own personnel, a manufacturer's service department, or BEST when actually performing the maintenance.

BEST has expanded its services as the technical needs of its clients have grown. It evaluates a client's planned purchase of equipment, much like a consumer group rates consumer-oriented products. The prepurchase evaluation gives the client a better understanding of the technical features of the planned purchase and a basis for comparison with competing models. The team inspects new equipment upon delivery for proper operation and possible damages. BEST also provides a client with safety inspections throughout the medical facility.

Although the Biomedical Engineering Systems Team operates as a service of the Regional Health Resource Center, it maintains a close working relationship with UIUC. Members of the Bioengineering Faculty provide continuing technical education and serve as consultants for BEST. Bioengineering students gain practical "hands on" experience under the supervision of an experienced technician. To date, UIUC students have participated in the development of procedures for evaluating equipment and in preventive maintenance programs as well.

The constant feedback of information between the Bioengineering Faculty and BEST engineers and technicians is providing the basis for further cooperative efforts. It may be possible, for example, to develop clinical engineering courses that would prepare students for technical specialization in the medical field. It is anticipated that future problems encountered by the team will generate additional research efforts at UIUC.

A direct development of UIUC research, the Biomedical Engineering Systems Team represents the important contributions that an academic institution can make to its community. Equally important is the idea of a cooperative technical service. BEST makes it possible for a group of hospitals to share a service that none could afford individually. For hospitals faced with a similar problem elsewhere, BEST may well be the best solution. ●



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     3  TEMPERATURE          1700
     2  VIBRATION              20




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With decision-making computer facilities on board an airplane, the pilot gains, in effect, a quick-thinking copilot. The computer system can monitor the plane for possible trouble and can clearly present essential data on its terminal screen. Computer-aided decision making in an aircraft environment is a current topic of research at UIUC's Coordinated Science Laboratory.

FLYING ACE

If researchers at the University of Illinois at Urbana-Champaign are successful, "pilot to computer" may one day become standard inflight jargon.

Work is being conducted at UIUC's Coordinated Science Laboratory (CSL) to develop computer systems and programs capable of high-level decision making. A team of researchers is investigating computer-aided decision making in an aircraft environment, under the direction of Robert T. Chien, director of CSL. Once developed, the programs would offer several communication alternatives to the pilot. The computer could be programmed to relieve the pilot of the decision making for certain tasks. Or, the computer could be assigned a background role, to monitor the airplane's operation for danger situations. Finally, the pilot could utilize the decision-making capabilities of the computer on an arbitrary basis.

A decision-making capability implies that the computer can not only recognize a crisis situation but can also correct it. For example, a center of gravity (cg) problem often arises from an imbalance of fuel in the tanks on both sides of the airplane. Yet the cg problem itself is the result of another problem, perhaps a leak in one of the tanks. The ability of the computer to analyze a cg situation and to choose the proper corrective action from several alternatives is the distinguishing feature of a high-level computer system.

In addition to decision-making programs, the research team is developing other advanced programs. One, a master monitor system, alerts the pilot to an emergency situation and provides him with a complete analysis of it. The pilot can choose to correct the problem himself or he can direct the computer to undertake the corrective action. A second program is designed to deal with a multiple crisis situation. In the face of many trouble spots, the computer system exhibits a sense of emergency and establishes a priority list to handle the most urgent problem first.

A pilot's own decision-making process can easily be subjected to intense pressure in the face of an emergency. The situation demands that the pilot concentrate his efforts in order to correct the problem quickly. The advanced computer programs operate under the same "real time" constraints. The goal is to develop a high-level decision-making computer system that works with the pilot under strict inflight time limitations.

Research with higher level computer programs is not designed to computerize the task of piloting an aircraft. Rather, computer systems with decision-making capabilities are intended to augment human observation and to provide additional flight analyses. In effect, the pilot will not be losing his controls to a computer but gaining a copilot. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

COLLEGE OF ENGINEERING
VOL. 18, NO. 9, APRIL 1977

inside outlook:

THE DYNAMICS OF PARKING
PAPER MONEY IDENTIFIER FOR THE BLIND
USING HEAT-TRANSFERRING FINS IN LIQUIDS
ION FUSION INVESTIGATED AT UIUC
MEN AND IDEAS OFFERED AGAIN

DEFENSIVE PARKING

"Drive defensively" is a well-known slogan that has probably helped to save many lives over the years. While motorists have never been urged to "park defensively," it appears that many motorists do. People will often choose one parking spot over another space if it seems to be safer for their car.

Defensive parking is just one of many factors that can influence a person to choose a parking space or parking lot, according to James H. Trail, the traffic engineer at the University of Illinois at Urbana-Champaign. Trail recently completed a proposal for the evaluation of parking facilities in a university setting as his dissertation for a doctoral degree in civil engineering. The research was directed by Professor John E. Baerwald of the College's Highway Traffic Safety Center. Trail studied the parking programs at several midwestern universities with particular emphasis upon the facilities at UIUC.

The most obvious reason why a person chooses a particular parking lot is its closeness or proximity to a destination. Safety to the individual and his car, and the price of parking are important factors as well. Trail found, however, that the problem of transportation storage — specifically, a parking program or a community's system of parking lots — has been overshadowed by research concerning transportation systems or highways. Consequently, Trail has developed a set of factors with which to evaluate a university's parking program.

Both service factors and physical factors are used to measure various aspects of each lot in a parking system. For example, the contributing area is a service factor that measures the proximity of the lot to the parkers' destination. It is likely that drivers would consider a parking lot on campus to be more attractive than one at the edge of campus. Other service factors include the area's traffic volume, the university's population density, and the number of registered parkers in the contributing area. Physical factors measure the actual physical condition of the lot. The amount of lighting and the width of the parking space are two physical factors among others that help to describe and evaluate a parking lot.

Service and physical factors can be rated by assigning a value from a specified range of numbers. In addition, a priority rating can be established from a mathematical model that describes the dynamic relationship among the various factors. The priority rating allows an administrator to evaluate a parking lot by itself and as part of the overall system. A low rating, for example, may indicate a need for physical improvements if the lot is well-situated in the system. An evaluation of a university's parking program with an established set of factors and priority ratings also provides a basis for decisions concerning additions to the parking system.

Although the study of parking programs was limited to a university setting, the concept of measurable factors to evaluate parking programs is useful to all communities. For instance, a city could use these factors in planning for the future parking needs in its downtown area. It may be that Trail's proposals will help to pave the way for better and more efficient parking. ●

A CREATIVE REACTION

Engineering is both a creative and a reactive discipline. It is creative in the sense that an engineer spends much time creating solutions to a variety of problems. And, it is a reactive discipline because engineers respond to specific and existing situations with problem-solving designs.

The dual nature of engineering is exemplified by a UIUC engineering student's solution to a very specific problem.

In 1975, David Lubar, a senior in the Department of Electrical Engineering, became aware that blind cashiers needed a device to help them identify paper money. While commercial money identifiers for the blind exist, their usefulness is limited. Lubar consulted with William G. Albright, an electrical engineering professor at UIUC. Both men felt that a more functional solution to this problem could be engineered.

Talking with his blind friends, Lubar found that the most useful type of identifier should have certain features. In addition to being inexpensive, the unit should identify paper money quickly and be able to identify either side of a bill as well. Furthermore, it should provide tactile output, that is, it should communicate with the user by touch. At first, Lubar thought that he could modify one of the existing commercial units. All of them, however, proved unsuitable with respect to the required features. For example, a light-scanning identifier emits a unique pattern of changing sounds for each denomination only if it is passed over the back of the bill.

Existing identification devices scan or read the back of a bill by reflecting light off its surface. Lubar's unit identifies paper money by passing light through a folded bill. Fixed areas on the surface — each area is about the size of a pinhead — are examined for the light and dark patterns that result from the interaction of the light and the ink. Tiny sensors (photodiodes) inside the machine can determine if the paper money is a \$1, \$2, \$5, \$10, or a \$20 bill because each denomination has unique light patterns at these spots. After a bill's value is decoded, one of five metal plungers is triggered, making contact with the user's fingers at the top of the machine. Each plunger corresponds to a particular bill amount, enabling the user to determine the value of the bill by touch.

UIUC engineering student David Lubar is demonstrating a paper money identifier for the blind which he designed and built. The user folds a bill around a clip, inserts it into the machine, and receives an identifying signal from one of five metal plungers at the top of the machine. Lubar's device is able to identify \$1, \$2, \$5, \$10, and \$20 bills.

Lubar's machine identifies paper money regardless of which way a folded bill is placed in the machine. Equally important, the unit can be built at a reasonable cost, probably under \$100. Yet, Lubar has found that the machine is not foolproof. An improperly cut bill or one with ragged edges can shift the fixed areas which are examined for light patterns. As a result, the sensors evaluate the wrong light patterns, causing misidentification. Interestingly enough, Lubar has found that soiled bills work well in the identifier if the edges are properly cut.

Lubar's invention is unique in many ways. Most important, it represents an attempt by the engineering student to build a paper money identifier with features that meet the needs of its users. Lubar is currently working to overcome the limitations of the unit and to reduce its size. Given his success at this point, it's easy to see that Lubar has engineered a solution to a problem with creativity and insight. ●

ALL FINS AND NO FISH

There's a chemical engineer at the University of Illinois at Urbana-Champaign who has been investigating fins for fifteen years. One might think that this researcher has accumulated a good supply of fish tales (as well as fins) but this is not the case. The researcher does have a heat exchanging device, however, that uses metal fins to transfer heat to liquids.

Fins are extensions on a larger metal surface, such as a car radiator, that act to dissipate heat from the metal body. Fins increase the rate of heat transfer because they expose more of the metal surface to the air. Although fins cannot always be used to affect a better heat exchange, the efficiency of fins can be controlled in situations where fins are applicable. The rate of heat transfer by a fin is directly influenced by the characteristics of the fin itself. Consequently, engineers attempt to optimize these characteristics such as the shape of the fin, the amount of spacing between fins, and the total number of fins on the metal surface.

For many years, fins were not used to affect the rate of heat exchange between a metal body and a boiling liquid. It was assumed that the heat-transferring ability of fins in liquids was too low to be efficient. In a series of experiments that involved microsecond photography, Professor J. W. Westwater, head of UIUC's Department

Although one-fiftieth the size of a conventional tube-and-shell condenser, the compact plate-fin heat exchanger in the right of the photograph can transfer a comparable amount of heat to the boiling liquids flowing through it. The construction of the prototype exchanger in UIUC's Department of Chemical Engineering used 34,000 heat-transferring fins to achieve a greater efficiency for its small size.

of Chemical Engineering, demonstrated that fins could be effective conductors of heat in boiling liquids (see *Engineering Outlook,* November 1971). A major factor influencing the exchange of heat by fins in liquids was the shape of the fin. Westwater found that certain designs, such as mushroom and cone shapes, were better than other shapes in a given situation. Additional experiments were conducted to determine the effect of such factors as spacing and number of fins upon the rate of heat exchange for fins in boiling liquids.

A subsequent project concerned the actual application of heat-transferring fins in boiling liquids. Westwater and his staff were able to obtain a prototype model of a compact plate-fin heat exchanger. Although the compact exchanger is only one-fiftieth the size of a conventional tube-and-shell condenser, it transfers a comparable amount of heat to the boiling liquid flowing through it. The prototype exchanger can transfer about 50 kilowatts (175,000 BTUs per hour) which is roughly equivalent to the amount of heat that is exchanged in a twelve-room house. The use of a large number of fins — about 34,000 — in the compact heat exchanger allows for greater efficiencies in the rate of heat transfer as well as greater savings in space, size, and materials.

In the current phase of the research, Westwater is attempting to further increase the effectiveness of heat-transferring fins. A pump is being used to induce a force flow, pumping the liquid over the fins at a constant rate. There may be an optimal range of velocity that contributes to an overall increase in the rate of heat transfer by fins to a steadily moving boiling liquid. Although this research remains to be completed, it seems definite that metal fins in boiling liquids provide a cool solution to a hot problem. ●

NO CON-FUSION HERE

Most people are aware that nuclear energy is produced by a process known as fission. Few people, however, are familiar with fusion, another type of nuclear energy-producing process. Fusion is being investigated by researchers around the world as a means to supply energy on a large scale. Among those researchers are Joseph T. Verdeyen and Blake Cherrington, professors in the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign.

Fusion can be directly contrasted with the more widely used fission process. In fission, energy is generated by separating the nucleus of a particle, while fusion energy is produced when the nuclei of certain particles are fused or combined. It is known that fusion offers several advantages as a practical source of energy. It uses materials that are more plentiful and less harmful than the materials used in the fission process. In fact, both fresh water and sea water contain an abundant supply of these materials. Furthermore, it is likely that a nuclear fusion-based power plant would have a less severe environmental impact than a nuclear fission-based power plant.

Because fusion energy is a complex process, researchers are investigating it in a number of ways. One approach is called inertial confinement in which a small solid pellet of fuel is rapidly heated to a very high temperature, about 100,000,000 degrees Kelvin. At this point, the fuel ignites and energy is produced. In order to heat the pellet, however, energy must be deposited on the pellet in a very short period of time, approximately one-hundredth of a millionth of a second! This requires an instantaneous power level that is one hundred times greater than the power-generating capability of the United States. Consequently, the basic problem facing researchers is to deliver energy to heat the pellet in a short time period.

In UIUC's Gaseous Electronics Laboratory, Verdeyen and Cherrington are approaching this problem using an ion beam. The researchers are attempting to group the ions so that they hit the pellet all at once. The situation is comparable to a kickoff in a football game where all eleven players on the defending team hit the receiver all at once. In both instances, the purpose is to deliver the maximum amount of energy to a target in the shortest time possible. On the football field, this is called effective kickoff coverage; in the laboratory, this technique is called ion bunching.

While this analogy simplifies the concept of ion bunching in fusion energy, it does indicate the difficulty facing the researchers. Nonetheless, Verdeyen and Cherrington hope to prove that ion bunching is feasible at high energy levels and at present stages of technology. This is a goal that will undoubtedly take much of their time and energy. ●

THE IDEAS BOOK

Some of the world's best engineering ideas originated at the University of Illinois at Urbana-Champaign. Twelve of these ideas are presented in the specially prepared volume, *Men and Ideas in Engineering: Twelve Histories from Illinois.*

Men and Ideas was first released in 1967 to commemorate the one hundredth anniversary of engineering education at UIUC. It's a fascinating, informal account of a dozen men, their co-researchers, and the basic engineering principles that resulted from their work. Among the notables is "the man that history forgot," but UIUC still remembers, Joseph Tykociner, the engineer who gave the world the first demonstration of sound-on-film movies in 1922 at UIUC. Other notables include Arthur N. Talbot, Arnold Nordsieck, and John Bardeen.

A hardcover edition of *Men and Ideas* is once again available from the Engineering Publications Office for $3.00, $1.50 for UIUC students, plus a 5% sales tax. At these prices, it's a book that all engineering students and practitioners will want to own. Send your order to Engineering Publications Office, 112 Engineering Hall, Urbana, Illinois 61801. Payment must accompany orders under $5.00 and checks should be made payable to the University of Illinois. ●

PEOPLE AND PLACES

Professor **Edward J. Cording** of the Department of Civil Engineering has been appointed the chairman of the subcommittee on education and training of the U.S. National Committee on Tunneling Technology. The subcommittee's task is to encourage the improvement of the education and training of engineers by educational institutions and by on-the-job education.

Gary B. Schuster, a graduate research assistant in the Department of Metallurgy and Mining Engineering, has been awarded a Sloan Fellowship for basic research. Schuster is one of ninety-five young scientists from over fifty colleges, universities, and research institutions, to receive a two-year research grant from the Alfred P. Sloan Foundation.

The American Association for the Advancement of Science (AAAS) has named Professor **Ven Te Chow** of the Department of Civil Engineering a fellow of the AAAS. Chow was cited for his "world-wide contributions to hydroscience."

Professor **Lee H. Sentman III** of the Department of Aeronautical and Astronautical Engineering has received the University of Illinois Loyalty Award from the department as one of its outstanding alumni. ●

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COLLEGE OF ENGINEERING
VOL. 18, NO. 10, MAY 1977

inside outlook:

METAL CUTTING USED IN ENERGY MANAGEMENT
CONSTRUCTING BRIDGE DECKS WITH EXPANSIVE CONCRETE
UIUC HONORS ALUMNI, FACULTY AND STUDENTS
SUPERNOVAE INVESTIGATED FOR X-RAY BURSTS

THINGS THAT GO BUMP IN THE NIGHT (OR DAY)

Some researchers are fortunate because their work manages to create an impact of its own. There is a team of three engineers at the University of Illinois at Urbana-Champaign who are even more fortunate in this respect. Their research not only manages to create an impact but it also manages the energy created by that impact.

Professors Thomas F. Conry, L. Daniel Metz, and Michael H. Pleck of the Department of General Engineering are specifically involved with the management of energy resulting from a collision. Kinetic energy is dissipated whenever a moving object collides with another moving object or a stationary object. A common example of this is an automobile that careens into a brick wall. Energy is usually dissipated in an unorganized manner, cracking the wall, smashing the front of the auto, and jolting the passengers. The term energy management refers to the dissipation of collision-caused energy in a controllable and organized manner. Its purpose is to minimize human injuries and damage to equipment.

One approach to this problem is to create a device that absorbs the energy generated from an impact. This is the basic principle behind the development of metals that crumple easily upon impact and aluminum utility poles that snap at the base when hit. A second approach is to develop a device which allows a controllable amount of deformation without permanent damage. The braking system on any automobile is a perfect example of this approach. And, the energy-absorbing five-mile-an-hour bumper is a more recent development of a limited damage energy management device.

The UIUC team has adopted the first approach in its investigation, designing a metal-cutting device that absorbs or utilizes collision energy. In its simplest form, the unit consists of a metal rod with a gradually increasing diameter and two sharp-edged metal cutting tools, placed directly above and below the narrow length of the rod. The unit is placed on a vehicle so that it intervenes between the vehicle and a barrier. On an automobile, for example, it is attached to the front and rear bumpers. Upon impact, the bumper collapses, pushing the wide end of the rod against the metal cutters. Collision energy is used to shave off the wider portion of the metal rod as it is pushed against the cutting edges.

There are two major factors that affect the development of a metal-cutting energy management system for a given situation. One factor is the acceptable limits for the severity index. The index is a measure of the damage to the human body as a function of deceleration or slowdown in a collision. The second factor, the deceleration profile, charts the decreasing speed of a vehicle over time. Use of metal cutting to manage collision energy results in a constant rate of deceleration, in contrast to a sudden stop. This is an extremely favorable characteristic of this system because human damage is minimized whenever a vehicle decelerates smoothly rather than abruptly.

Because a decelerative metal-cutting unit must be replaced after each use, its greatest potential for use will probably be in transportation fields where the rate of collisions is low. While this may exclude automobiles, it does include trains, subways, and elevators. With elevators, the unit would be placed at the bottom of the shaft. In the case of subways, the units would be installed at each end of a line. In fact, the new subway in the U.S. Capitol building uses metal-cutting units in its energy management system.

Although metal cutting is an effective way to control collision energy in certain situations, at present it is not widely used. Nonetheless, it seems certain that the proposals of the UIUC team concerning this form of energy management will generate much energy upon impact. ●

ALL DECKED OUT

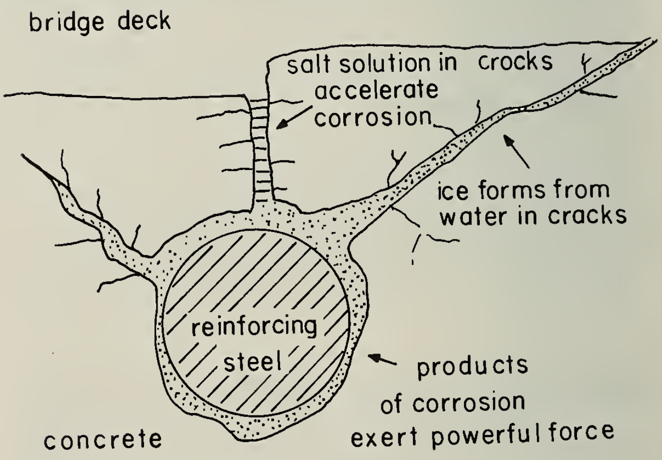
Although London Bridge stands upright in Arizona, many highway bridges in rural and urban America are close to cracking up, if not falling down. In fact, bridge deterioration is a serious transportation problem in the United States. At the University of Illinois at Urbana-Champaign and other institutions across the country, research is being conducted to explore and to control the causes of bridge deterioration.

A major area of research concerns the deterioration of concrete bridge decks. Although cracks in the concrete are not a serious problem by themselves, cracking is aggravated by the use of chloride salts to de-ice the bridge surface during the winter months. Cracks may be deep enough in some concrete decks to enable salt and water to reach and corrode the steel reinforcing rods within the concrete. Corrosion causes pressure to be exerted along the cracks and, ultimately, surface depressions, by separating and removing the concrete. This type of defect is known as spalling.

Spalling is considered to be the most serious type of bridge defect because it weakens the bridge deck in spots and it increases the likelihood of additional corrosion and damage. Both traffic and repair work are made more difficult by spalling. Several methods have been developed and are used by highway engineers to combat this problem. One approach is designed to prevent corrosion by coating the steel rods with a resistant substance. A second technique is designed to protect the concrete surface from salt and moisture by applying an asphalt sealer.

Professor Clyde E. Kesler of UIUC's Departments of Theoretical and Applied Mechanics and Civil Engineering has been investigating the use of expansive concrete in bridge deck construction. This preventive technique uses expansive cement, an ingredient of concrete which causes it to expand in size as it is cured or kept moist. Kesler has demonstrated that expansive concrete can be used to construct bridge decks with thicknesses to 20 cm (8 in.). Kesler has also determined the factors which affect concrete expansion and the means to control these factors to obtain adequate expansion.

While expansive concrete shrinks as it dries, the loss in size is compensated by its original expansion. In contrast, regular concrete, which is currently used in bridge decks, experiences shrinkage without the initial expansion. Excessive shrinkage of regular concrete after the curing process is the major reason for extensive cracking and subsequent deterioration of bridge decks. While expansive concrete cannot eliminate cracking entirely, it can improve the durability of bridge decks. The purpose is to extend the life of the deck before serious trouble develops. Although expansive concrete costs slightly more than regular concrete, it can be more economical and efficient in the long run. The investment in materials can be recovered several times over the longer useful life of a bridge deck. Since repair work is a costly operation in itself, use of expansive concrete in bridge decks may be all that it's cracked up to be. ●


bridge deck
salt solution in cracks accelerate corrosion
ice forms from water in cracks
reinforcing steel
products of corrosion exert powerful force
concrete

Cracks in concrete bridge decks provide a means for water and salt to reach and corrode the steel reinforcing rods within the concrete. The primary effect of corrosion is to damage the concrete at the surface of the bridge, causing costly repairs to be made. A researcher at the University of Illinois at Urbana-Champaign has demonstrated that expansive concrete can be used instead of regular concrete to control cracking and subsequent deterioration of the bridge deck.

SPRINGTIME IS THE RIGHT TIME

Although a young man's fancy turns to many things in spring, the College of Engineering of the University of Illinois at Urbana-Champaign takes a fancy to honoring alumni, faculty members, and students each spring. Awards were recently presented to the 1977 recipients at the college's thirteenth annual honor awards convocation.

The Alumni Honor Awards for Distinguished Service are given to those graduates of the College of Engineering who have distinguished themselves by outstanding leadership in the planning and direction of engineering work, by fostering professional development of young engineers, or by their contributions to knowledge in the field of engineering. 1977 recipients of the alumni awards are: Charles H. Mottier, Sr. (retired vice president, Illinois Central Railroad, B.S. civil engineering 1910); Roy J. Carver (chairman of the boards of Carver Industries and Bandag, Inc., B.S. general engineering 1934); John

D. Nyquist (vice president emeritus and consultant, Collins Radio Company, B.S. mechanical engineering 1941); Daniel L. Dudas (president, System Development Corporation, B.S. aeronautical engineering 1956, M.S. aeronautical engineering 1957); and O. Thomas Purl (vice president, Devices Group of Watkins-Johnson Company, Ph.D. electrical engineering 1954).

A number of undergraduate students are the recipients of college awards. They include: Sharon M. Stefanik (general engineering), the Honeywell Award for distinguished performance and leadership; Thomas S. Wittrig (chemical engineering), the Lisle A. Rose Memorial Award for technical and cultural excellence; Jane C. Westmiller (electrical engineering), the Harvey H. Jordan Award for scholastic standing and character; and William D. Harris (electrical engineering) and William L. Streicher (ceramic engineering), the Stanley H. Pierce Award for development of student-faculty empathy.

Faculty member Errol D. Rodda of the Department of Agricultural Engineering is also a recipient of the Pierce Award as it honors both students and faculty members. The 1977 recipients of the Everitt Award for Undergraduate Teaching Excellence are Cristino Cusano of the Department of Mechanical and Industrial Engineering and Harry R. Wetenkamp of the Department of Theoretical and Applied Mechanics.

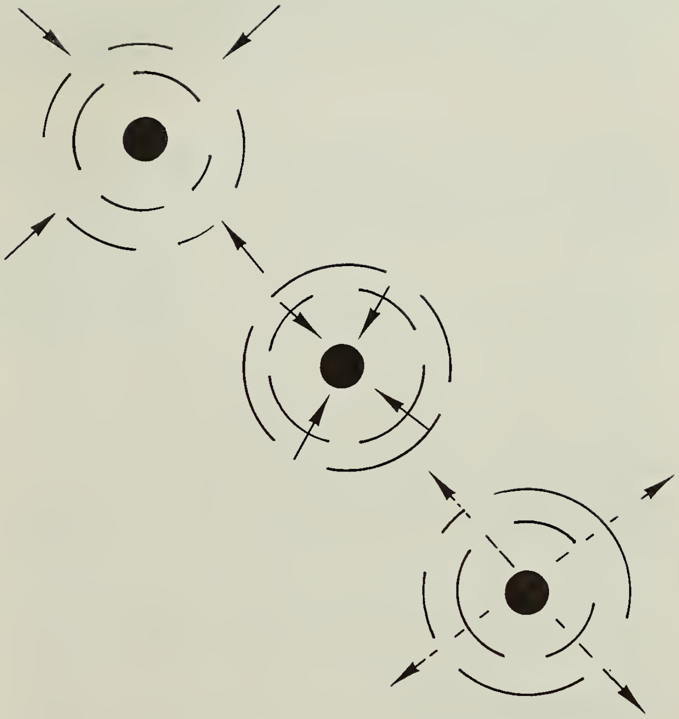
UIUC is as proud of the 1977 award winners as the winners are to receive this distinction. ●

X-RATED STARS

As every Hollywood agent knows, old stars are like old soldiers: they never die but only fade away. In contrast, a scientist could never make this generalization about the stars in his field. While some stars simply fade away or cool down, larger stars die with a flourish that surpasses anything a Hollywood agent could devise.

The flourish is actually a violent explosion that occurs at the end of a star's evolution or life. Scientists call this stage a supernova and it results in the destruction of a star in a few minutes. After the smoke (hot gases and plasma) clears, either a neutron star or a black hole is found at the site of the former star. Neutron stars and black holes are not ordinary stars but are considered to be the cinders or the condensed remains of exploded stars. The brief flash of a supernova and the appearance of a supernova remnant are important because both offer clues to the development and death of stars.

Research by physicists at the University of Illinois at Urbana-Champaign has revealed new information about neutron stars. The investigation was prompted by unusual bursts of x rays from space which were first detected by Soviet and Dutch satellites in 1975 and later verified by an American satellite. The bursts occur in the x-ray sky at roughly regular intervals, blinking on and off like Christmas tree lights. Each burst lasts from 5 to 10 seconds and each occurs at intervals of three hours to one day. To date, over twenty different sources of x-ray bursts have been identified and hundreds of additional sources are believed to exist in the galaxy.



It appears that neutron stars may be the source of periodic x-ray bursts that were first detected in 1975. The diagram simplifies an explanation of the bursts that has been advanced by a team of physicists at the University of Illinois at Urbana-Champaign. In the top illustration, gases and plasma from other stars are drawn to the neutron star, forming a boundary some distance from its surface. As the matter at the boundary cools, it becomes unstable and falls to the surface of the neutron star (middle diagram). This collision produces x rays only momentarily because the x rays expel the matter from the vicinity of the neutron star, causing the boundary to restabilize.

Professors Frederick K. Lamb, Donald Q. Lamb, and Mordehai Milgrom of UIUC's Department of Physics have been investigating this phenomenon. Their research is being conducted in cooperation with Professors A. C. Fabian and J. E. Pringle of the Institute of Astronomy in Cambridge, England. The group has advanced a theory that explains the x-ray bursts and is testing it by performing detailed calculations with computers.

It appears that a neutron star accretes matter; that is, it attracts plasma and hot gases from nearby stars with its gravitational pull. The matter collects at a spherical boundary some distance from the neutron star where it is held by the star's magnetic field. After a considerable amount of matter collects, it cools, causing an unstable situation in which gases and plasma plunge to the surface of the neutron star. The impact at the surface produces x rays which radiate from the neutron star.

Given the theory to this point, it might seem that x radiation by the neutron star would be continuous rather than periodic. A key point to the theory, however, is that the x rays interact with the matter which is still falling toward the neutron star. This interaction effectively reverses the flow of the matter and ends the x radiation. In other words, the neutron star experiences long periods of inactivity which are interrupted by short intervals of instability, as indicated by the x-ray bursts. The cycle is repeated as the expelled gases and plasma collect again at the neutron star's magnetospheric boundary.

Scientific discoveries such as the x-ray bursts challenge researchers not only to explain an occurrence but also to verify the explanation. This is the task facing the UIUC team of physicists. If their hypothesis proves correct, it may make them stars in their own right. ●

PEOPLE AND PLACES

Clyde E. Kesler, a member of the Departments of Civil Engineering and Theoretical and Applied Mechanics, and **Mete A. Sozen** of the Department of Civil Engineering, have been elected to the National Academy of Engineering. This is the highest honor which can be conferred on an American engineer. The election of Kesler and Sozen brings to twenty-one the number of UIUC faculty members who have received this honor.

The American Society for Testing and Materials (ASTM) has named Professor Emeritus **William A. Oliver** of the Department of Civil Engineering a member of the society. Oliver has also received the Award of Merit from the ASTM for distinguished service to the cause of voluntary standardization.

The American Institute of Aeronautics and Astronautics (AIAA) has named **Harry H. Hilton,** head of the Department of Aeronautical and Astronautical Engineering, to its national awards committee.

Nine members of the physics faculty have been elected fellows of the American Physical Society. They are: **John D. Dow, Shua-Jin Chang, Christopher J. Pethick, Myron B. Salamon, Harvey J. Stapleton, Wendell S. Williams, Michael Wortis, Manfred Raether,** and **A. Barry Kunz.** Fellows are elected for their contributions to the advancement of physics by independent and original research or for special service to the cause of the sciences. The election of these physicists brings to 43 the number of faculty members at UIUC who have received this honor. ●

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COLLEGE OF ENGINEERING
VOL. 19, NO. 1, AUGUST 1977

inside outlook:

UNIVERSITY-INDUSTRY FRACTURE CONTROL PROGRAM
NOVEL COAL GASIFICATION PROCESS
CANADIAN-U.S. RADIO TELESCOPE EXPERIMENT
ENGINEERING STATISTICS FROM UIUC

TRADE (-ING) SECRETS

The youth movement of the late Sixties popularized the generation gap while the political arena spawned the credibility gap. In the world of science, an information gap often exists between the college engineer who conducts research and the corporate engineer who applies the products of research to his company's needs. One way that engineers at academic institutions attempt to fill the information gap is to publish reports of their research findings. At the same time, it is virtually impossible for corporate engineers to keep pace with these reports because the volume of technical reports is so large.

The College of Engineering at the University of Illinois at Urbana-Champaign has developed a unique program that attempts to solve the information gap between academic engineers and corporate engineers. The Fracture Control Program consists of a group of UIUC engineers and several corporations who collectively sponsor research in the area of fatigue and fracture failures in machines and structural components. The purpose of the program is twofold: to address a major problem of industry through intensive research at the academic level; and to provide a way to communicate directly the findings of the college researchers to the corporate engineers. To achieve these goals, periodic advisory meetings are held between UIUC faculty members and representatives from the sponsoring companies to guide the research objectives for the Fracture Control Program. In addition, the College of Engineering schedules a three-day seminar twice a year at which engineers from the corporations are briefed in a specific aspect of the problem. The most recent seminar, for example, dealt with fatigue life prediction.

UIUC's Fracture Control Program has proven to be beneficial to both parties during its six-year existence. For the corporation, a sponsorship fee provides access to an interdisciplinary group of UIUC professors and graduate students (from the Departments of Civil, Metallurgy and Mining, and Mechanical and Industrial Engineering, and Theoretical and Applied Mechanics) as well as their research on fatigue and fracture failure. Thus, the program is a cooperative venture not only between the University and the corporations but also among the companies as they pool their research funds to support a wider range of study concerning a common problem. Corporate funding enables the College to establish positions for graduate students and to maintain a more comprehensive research program. And, the advisory meetings and seminars provide a valuable opportunity for interaction between the two groups of engineers.

Fatigue and fracture failures are common problems in ground vehicles which experience severe service conditions such as heavy repeated loads, extreme temperatures, and rugged surface conditions. Consequently, the work of the fracture control group is pertinent to the participating companies whose products — agricultural, construction, transportation, and mining equipment — experience these kinds of stresses. Current sponsors of the program are the Caterpillar Tractor Company, Clark Equipment Company, Deere & Company, Eaton Corporation, Exxon Corporation, General Motors Corporation, International Harvester Corporation, and Rexnord Corporation.

Professor Herbert T. Corten of the Department of Theoretical and Applied Mechanics is the chairman of the program. While many of the current sponsors are midwestern corporations, Corten is seeking additional sponsors among the many manufacturers of heavy industrial machinery throughout the United States as the research is particularly appropriate for their products. Additional information concerning the program can be obtained by writing the Chairman, Fracture Control Program, 321C Talbot Laboratory, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. It's one break that could prove worthwhile. ●

Fatigue and fracture failures can occur on a small scale and on a larger scale. A component from an impact-testing machine in the left of the photograph contains a fatigue crack which was caused by repeated impact. To its right, a steel section from the main output shaft of a cantilever bridge exhibits a brittle fracture which was prompted by extremely cold weather. Fatigue and fracture failures are the subject of a special cooperative research program between several corporations and the University of Illinois at Urbana-Champaign.

IT'S A GAS

Take sixteen tons of coal and what do you get? Ask Professor Shao Lee Soo of the University of Illinois at Urbana-Champaign and he would answer "gas."

This is not the way the song goes but Soo has good reason to change the words. A member of UIUC's Department of Mechanical and Industrial Engineering, Soo has developed a new method to obtain gas from coal. While many methods to gasify coal exist, Soo's method is unique. It uses steam alone to gasify coal in contrast to other processes which use steam and oxygen. Steam acts as both a reactant and a heat source in the Soo process. In other words, steam supplies the heat necessary for gasification and it also reacts with the carbon in coal to produce carbon monoxide and hydrogen, gases that can be further processed into liquid fuels.

The use of steam makes the Soo process a practical method to gasify coal as well. Since the steam reacts with carbon alone, all grades of coal can be used to produce gas. This is an important feature because much of the coal reserves in Illinois and the rest of the United States are high in sulfur. After reacting with carbon, the steam is condensed or cooled to water. This has the beneficial effect of removing impurities and other polluting particles from the gas. The result is almost colorless, very clear gas from all grades of coal. In addition, condensation enables the steam to be reused in the process, thereby making efficient use of water.

With the aid of R. T. Gibbs and K. T. Ma, research assistants in mechanical engineering, Soo has developed a model of a coal gasification plant with a capacity of 0.45 to 4.5 kg (1 to 10 lb) of coal per hour. Although the process has not been tested outside the laboratory, Soo estimates that a scaled-up model of 454 metric tons (500 tons) of coal per day would produce enough clean burning gas to supply the UIUC campus with all of its energy needs. He is currently working to increase the capacity of the experimental model.

Soo's gasification method is a timely development as it appears that coal will become a more important source of energy in the future. Considerable savings in energy costs result whenever coal is substituted for oil because coal supplies the same amount of energy as oil for less than one-half the cost. An economical and efficient method to gasify coal would enable the United States and other nations to make better use of their coal reserves. The development of a coal-based energy industry has implications for Illinois in particular, as this state has the second largest reserves of coal in the United States (after Montana). In fact, the amount of energy in the Illinois coal reserves is twice the energy in the oil reserves of Iran and equal to the energy in the oil reserves of Saudi Arabia.

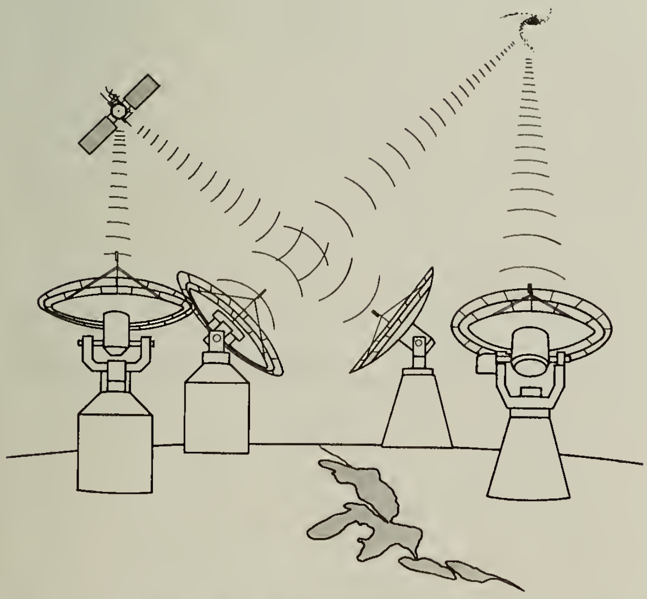
To date, the development of a coal-based energy industry has been limited by the lack of a satisfactory gasification method. Soo believes that his process overcomes the economical and environmental problems that have hampered the extensive utilization of other gasification processes. The UIUC researcher's gasification process may stimulate the further development of coal as an energy source, a development that may now proceed full steam ahead. ●

GETTING AN EARFUL

If Marc Antony had asked a group of astronomers to "lend me your ears," he probably would have received directions to the nearest observatory. There he would find a radio telescope, an electronic ear that enables the astronomer to "tune in" the universe. Because radio telescopes are an important source of information about the universe, scientists have sought to increase the sensitivity and precision of data from these facilities.

One way to accomplish this goal is to build a larger telescope. A second approach is called very long baseline interferometry, a technique developed in 1967 which coordinates observations of the same object in space with two widely separated telescopes. The effect of this procedure is to simulate a synthetic radio telescope of enormous dimensions and it results in data equivalent in many ways to data from a telescope with a diameter equal to the distance between the participating telescopes. Very long baseline interferometry has subsequently been used to link radio telescopes at continental and intercontinental distances, creating the equivalent of a giant-sized telescope, one almost the size of the earth itself.

Until recently, the technique had been hampered by delays in the shipment of tape-recorded data between facilities. Now, a joint team of Canadian and American astronomers has reported the successful use of a communications satellite to overcome this problem. In the experiment, the satellite transmitted data as they were being recorded at the National Radio Astronomy Observatory in West Virginia to the Algonquin Radio Observatory in Ontario, Canada. There, the data from both facilities were processed by computer. To synchronize the observations, a special delay system was added to the computer. It delays signals from the Canadian telescope to match the quarter-second delay of signals that travel from the observatory in West Virginia to the satellite and then to Canada.



Very long baseline interferometry is a technique which coordinates observations of the same object in space with two widely separated radio telescopes. The schematic drawing depicts an improvement of the technique which enables data from one telescope to be transmitted to the second telescope by a communications satellite, avoiding delays in the shipment of tape-recorded data between facilities. Professor George W. Swenson, Jr., of the University of Illinois at Urbana-Champaign, is the chairman of the joint Canadian and American team which achieved the development. (Illustration from artwork by J. W. Johnson, San Jose, California)

This latest development is the work of several research groups from both countries. The University of Illinois at Urbana-Champaign is represented by Professor George W. Swenson, Jr., of the Departments of Electrical Engineering and Astronomy. Swenson's participation in the project was funded by the National Science Foundation. The accomplishment of the group greatly increases the value of very long baseline interferometry as a practical technique for astronomers. Using the communications satellite, astronomers can obtain precise data in a matter of minutes. For example, it can be used to determine rapidly the size and shape of a distant galaxy with a precision of a thousandth of an arcsecond. This is equivalent to measuring the size and shape of a penny at a distance of 4025 km (2500 miles). Very long baseline interferometry can also be used as a type of global surveyor's tool, providing a method to measure — perhaps instantaneously — the movement of continents and to predict earthquakes.

The linking of two radio telescopes to create a super telescope has already proven to be a valuable tool for astronomers. Use of the communications satellite, however, represents a giant step in a more efficient application of the technique. ●

SIGNIFICANT AT ANY LEVEL

Statistical information is only useful if one knows how to interpret the data correctly. As far as the University of Illinois at Urbana-Champaign is concerned, there can be no mistakes about the meaning of the following statistics.

A nationwide survey of 200 engineering institutions reveals that UIUC ranks second in separately budgeted research expenditures. For fiscal year 1976, UIUC reports that $19,139,000 was generated for research within the College of Engineering. In addition, research in the major engineering-related units outside the College of Engineering was supported with $7,164,000 in funds. The UIUC total of $26,303,000 represents 7.7 percent of the more than $340,000,000 which was spent to finance engineering and engineering-related research in the United States last year.

UIUC also ranks high in terms of the number of engineering graduates at the bachelor's, master's, and doctorate levels. In fact, the University of Illinois at Urbana-Champaign is the only university in the nation to rank among the top five schools in each of these categories in 1976. UIUC's College of Engineering ranks second in the number of bachelor's degrees awarded, with 730; fifth in the number of master's degrees conferred, with 414; and third in the number of doctorates granted, with 135. In addition, UIUC again led the nation's schools in the number of degrees that were awarded in the combined fields of chemistry and chemical engineering. UIUC granted 285 degrees at the bachelor's, master's, and doctoral levels in these fields in 1976.

While these statistics indicate the extent of the research and educational efforts at UIUC, an indication of the quality of the education is the success of UIUC graduates in the job market. In this respect, both the students and UIUC fare well as 62 percent of the May 1977 graduates are working, the highest percentage since 1970. Furthermore, the average starting salary is $1,259 per month, an increase of $106 over the starting salaries of the May 1976 graduates. A survey conducted by the Engineering Placement Office indicates that 323 of the 522 May 1977 graduates have jobs and that 104 are in graduate school.

The University of Illinois at Urbana-Champaign is proud of its role as a leader in engineering research and education. In view of engineering's importance to the world, it is a role with more than just statistical significance. ●

PEOPLE AND PLACES

Professor **Harry G. Drickamer** of the Department of Chemical Engineering is the first recipient of the new P. W. Bridgman Award for outstanding achievement in high pressure research. The award is sponsored by the International Association for the Advancement of High Pressure Science and Technology.

The American Physical Society has appointed **Peter Axel** the chairman of its division of nuclear physics and **Hans Frauenfelder** a member of its council, division of biological physics. Both men are professors in the Department of Physics.

Professor Emeritus **Nathan M. Newmark** of the Department of Civil Engineering has been named to the advisory council of the School of Engineering of Stanford University. ●

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COLLEGE OF ENGINEERING
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inside outlook:

POLITICAL REDISTRICTING BY COMPUTER MODEL
FOOD FOR CENTURY III
CONTOUR PLANTING OF ROWCROPS
INTERNATIONAL PHYSICS WORKSHOP

PLAYING POLITICS

It's been said that many political decisions are made in smoke-filled rooms where the party boss wields his clout. Recently, two researchers at the University of Illinois at Urbana-Champaign have shown that political redistricting decisions can be cleared up with computerized clout.

Political redistricting is conducted every ten years after each census to redivide a state into areas of equal population for the purpose of representation. While there are many ways to arrange districts within a state, the task is simplified when district boundaries are made to coincide with existing boundaries, such as township or county lines. At the same time, political realities tend to complicate the task, as one party may propose a redistricting plan which favors that party in terms of voter registration. Despite attempts at gerrymandering, the practice of districting follows certain guidelines. The population of each district must be roughly equivalent to the population in each of the other districts. Each district should be somewhat compact, a condition which lessens the possibility of gerrymandering. In addition, areas within a district must be contiguous and not physically separated by other districts.

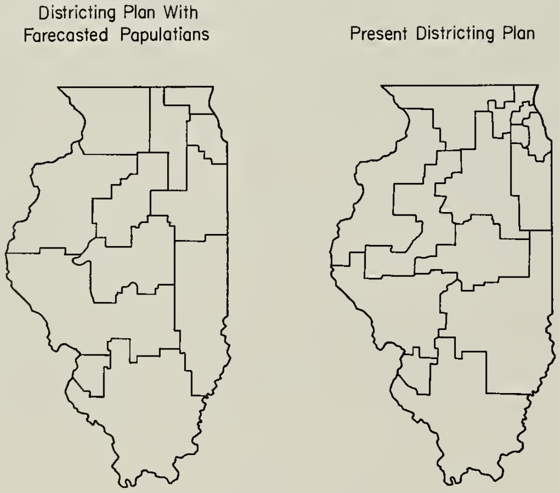
The political pressures of redistricting could be avoided by using computer models to mathematically subdivide a state into districts. Models are not only more efficient than committees but they are also apolitical and immune to the influence of politics and politicians. Several computer programs have been developed which use actual census data as input to a districting plan for the subsequent ten-year period. One problem of these models is that the districts tend to become less representative over the decade. This is particularly true when the state has experienced a rapid population growth.

A solution to this shortcoming has been presented in a master's thesis by industrial engineering student Thomas Rushing, with assistance from Judith Liebman, associate professor of operations research and a member of the Departments of Civil Engineering and Mechanical and Industrial Engineering. Rushing and Liebman have developed a computer model which prepares a districting plan for a ten-year period from a projection of the population at the midpoint of the decade. Projections were obtained by analyzing historical population data with a simple forecasting model. The projected data then serve as input to the redistricting model, instead of actual census data. As an example, Rushing and Liebman's model would use the projected 1985 population figures for counties within Illinois to prepare a redistricting plan for the period 1980 through 1990. Ideally, the researchers' model would propose districts which would correspond better with the actual population of each district at the midpoint and latter half of the decade.

Rushing and Liebman used the state of Illinois as a test for their model. In one instance, actual 1970 census data were programmed into the model; in a second test, projected population data for 1975 served as input. The resulting arrangements of districts from each test was compared to the actual districting plan in Illinois. In addition, the representativeness of the proposed plans was estimated by calculating the total deviation or difference in population for all districts from the average population per district.

As the researchers expected, the test of the model using real data resulted in a districting plan that was similar to the actual plan in Illinois. And, the test which used projected data proposed a different pattern of districting within the state. Statistical analysis also supported the premise of Rushing and Liebman. The districting plan from real data was initially more representative, as the total deviation from the average population per district was small; by 1980, the deviation was projected to be larger. In an opposite manner, the districting plan from projected data corresponded less well with actual population during the initial part of the decade but it became more representative by 1975, as the population increased in line with the forecasts.

Although Rushing and Liebman have increased the sensitivity of computer districting models, they recommend that the models should only be used on a limited basis, to provide a starting point for a new plan or to evaluate a committee's proposal. Nonetheless, the UIUC researchers have shown that playing politics can be as simple as reading a computer printout sheet. ●


Districting Plan With Forecasted Populations

Present Districting Plan

UIUC researchers used forecasted (1975) population data to hypothetically redistrict Illinois for the period 1970 through 1980. As the maps indicate, the resulting arrangement of districts differs considerably from the actual districting plan, which is based on the 1970 census. Use of forecasted population data as a basis for redistricting results in a plan that better corresponds to changes in population through the ten-year period.

FOOD FOR THOUGHTS

A hungry man dreams only of food while a well-fed man is free to dream great things. Throughout history, the existence of an adequate food supply has enabled man to turn his attention to the development of a better society. At the University of Illinois at Urbana-Champaign, a program has been proposed which positively affects man's ability to feed himself.

The program, called Food for Century III, is a plan to improve the physical facilities at UIUC that are involved in food production. While Food for Century III is primarily concerned with activities in the Colleges of Agriculture and Veterinary Medicine, it includes the research programs and academic activities of the Department of Agricultural Engineering in the College of Engineering. The centralization of related programs in the three colleges is to be accomplished through the renovation of existing buildings, construction of new facilities, and the purchase of additional farmlands and equipment. A major goal of Food for Century III is to provide more modern and efficient facilities for agriculture-related educational programs. It also provides the means to improve and expand the scope of food production research and agricultural extension programs at UIUC.

The Department of Agricultural Engineering is to play a key role in Food for Century III. Under current plans, the department is to be housed in a new building, the Agricultural Engineering Sciences Building, with the wood sciences program of the Department of Forestry and the food engineering program of the Department of Food Sciences. The relocation of these programs in one building illustrates the coordinated approach of the master plan — that is, to group specific activities which are related aspects of the agricultural process. Food engineering, for example, is concerned with the preparation of raw produce, such as grain, for consumption. Before the food engineer can recommend ways to prepare the grain, however, the agricultural engineer must direct the use of the proper agricultural techniques and equipment to plant and harvest the grain. Working together, the food engineer and the agricultural engineer may be able to increase the efficiency of the complete process — from growing grain in the field to preparing the food product for the table.

While funding for the initial phase of the project has already been approved by the Illinois General Assembly, Food for Century III in its entirety is a challenging project that will take eight years to complete. The task of producing food to feed a growing world population is a major challenge. The direct result of the plan is to increase UIUC's ability to respond to the needs of the food producer and the problems of food production, both within Illinois and abroad. In a more general sense, Food for Century III represents man's continuing efforts to build a better world. ●

A HILLY ROW TO HOE

Can a square peg fit into a round hole? This problem is often presented to young children as a game and they spend a considerable amount of time and energy trying to solve it. Many American farmers are faced with a similar problem and agricultural engineers at the University of Illinois at Urbana-Champaign are attempting to solve it.

From the air it appears that farmers are playing games when they plant rowcrops in curving patterns instead of straight lines. The height hides the fact, however, that the land is not flat but sloping. Rowcrops such as corn and soybeans are planted across the slope — a technique called contouring — to prevent erosion from rainwater runoff. Contour planting is a land-forming method that is used to modify the form or profile of a field for cultivation. While the technique helps to conserve the soil, it creates a square peg–round hole dilemma for the farmer because farm equipment is basically designed for straight line operation. Fields are not rectangular and machine operators are faced with small, irregular tracts that are difficult to process efficiently. Time and energy costs of production are increased when modern multirow machines are used on short rows and at less than full width.

The rise in overhead costs is a problem that is becoming more severe for farmers as choice flat farmland becomes scarce. In some instances, urban sprawl — housing projects, shopping centers, highways, and other developments — has limited the availability of prime tracts of land. Elsewhere, farmers have turned to hilly fields, often reserved for grazing, to increase their acreage under intense production. Use of special land-forming techniques such as contour planting and terraces (planting crops in step-like rows up the side of a hill) becomes necessary when the slope of the land exceeds 4 percent.

Professor Donnell R. Hunt of the Department of Agricultural Engineering is developing a model to direct the land forming of hilly fields in order to minimize the total cost of crop production. Hunt is being assisted by Kwan Hee Ryu of South Korea, a nation where terrace farming of rice is extensive. The researchers have determined that the total cost of cultivating slopes consists of three basic subcosts. Initially, the cost of preparing the land — surveying, grading, terracing, and leveling — depends on the technique. This cost is greatest when the slope is radically modified (such as bench terracing) and it is minimized when the slope is left untreated. The second expense is the cost of erosion itself, which is reflected by reductions in soil fertility, actual soil loss, and the amount of downstream siltation in streams and ponds. The expense of operating equipment is the final subcost and it is based on the time and energy requirements of each machine.

The relationship among the subcosts is expressed mathematically in the model. Erosion, for example, is reduced with increased amounts of land forming; at the same time, the cost of operating farm equipment tends to increase with the amount of contouring. The model provides a comprehensive or systems approach to the problem because it includes the cost of all stages of the agricultural process. Its goal is to minimize individual subcosts while maintaining crop yields and minimizing total costs. Since the subcosts — land forming, erosion, and machine operation costs — can be estimated from real data for a piece of land, the model is solved for a range of slopes, from 3 percent to 20 percent.

Hunt and Ryu's research indicates that the slope of the land is the most important determinant of total cost. At the same time, the researchers — and the model — recognize that the use of land-forming techniques must be guided by the costs of erosion and machine operations. Their goal is to ensure that the only thing growing down on the farm are the crops and not the overhead. ●

Farmers are not playing games when they plant crops in swirling patterns instead of straight lines. They use contour plowing and other land-forming methods to prevent erosion from rainwater runoff in sloping fields. At the same time, these techniques increase the time and energy costs of operating farm equipment. Agricultural engineers at the University of Illinois at Urbana-Champaign are investigating ways to reduce these costs through the proper use of land-forming techniques.

HIGH-LEVEL MEETING

The Department of Physics at the University of Illinois at Urbana-Champaign recently hosted an international workshop, "Nuclear and Dense Matter." The four-day event attracted sixty physicists from Belgium, Canada, Denmark, England, France, Germany, Italy, and Mexico, as well as the United States. Among the participants was Hans A. Bethe of Cornell University, a 1967 Nobel Prize winner and a George A. Miller visiting professor at UIUC. The workshop was organized by Professor Vijay R. Pandharipande of the Department of Physics.

The physicists discussed research and the problems of studying the basic forces which hold the atomic nucleus together. A better understanding of these forces is vital to progress in a number of areas, including the further development of solar and nuclear energy. Since the participants and their individual research efforts are widely scattered around the world, the workshop at UIUC provided an opportunity for the physicists to discuss matter that matters. ●

PEOPLE AND PLACES

The Western Electric Fund Award for outstanding teaching and research as been presented to Professor **George H. Miley**, the chairman of UIUC's Nuclear Engineering Program. The award is sponsored by the Illinois-Indiana section of the American Society for Engineering Education.

Professor **Joseph E. Greene** of the Departments of Mechanical and Industrial Engineering and Metallurgy and Mining Engineering has been named to a half-time revolving assistant deanship in UIUC's College of Engineering. Greene is the ninth person to hold the revolving deanship, which was established in 1969 to provide additional student and department contacts for the Associate Dean's Office.

The American Society for Engineering Education has presented the George Westinghouse Award to **Roger A. Schmitz** of the Department of Chemical Engineering. The award is designed to honor a young engineering educator for excellence in teaching.

Ven Te Chow, professor of hydraulic engineering in the Department of Civil Engineering, is the recipient of the 1977 Vincent Bendix Award — the highest research award of the American Society for Engineering Education — for his outstanding research contributions and administrative leadership in engineering education.

Professor **Robert A. Eubanks** of the Departments of Civil Engineering and Theoretical and Applied Mechanics has been elected to a three-year term on the executive committee of the National Consortium for Graduate Degrees for Minorities in Engineering.

The American Society of Agricultural Engineers has presented the 1977 Hancor Soil and Water Engineering Award to **Benjamin A. Jones, Jr.**, agricultural engineering professor and associate director of the Agricultural Experiment Station. The award is sponsored by Hancor, Inc., of Findlay, Ohio, and recognizes noteworthy contributions to the advancement of soil and water engineering. ●

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COLLEGE OF ENGINEERING
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inside outlook:

TEAM RESEARCH ON FLOOD CONTROL
INCREASING CORNEAL CURVATURE
SUPPORT POLE PERFORMANCE
PAUL F. KENT MEMORIAL FUND

WHEN IT RAINS, IT POURS

The rain in Spain may fall mainly in the plain, but it's a sure bet that most of it flows down the river. The same can be said for the rest of the world, particularly during times of heavy rainfall. At the University of Illinois at Urbana-Champaign, a research team is using a new approach to control flood damage from severe rainstorms wherever it occurs.

Perhaps the most obvious solution to the problem of flooding along a river or stream is to build a dam upstream where water collects, or a levee downstream where floods occur. Retaining devices such as dams and levees are structural solutions to the problem, but they are not always the best solutions. Flood prevention structures are costly in terms of money, time, and land requirements. Furthermore, they do not provide absolute protection against floods because they are built to withstand limited amounts of water. Equally important, these structures encourage further urbanization along the river which can result in increased property damage when an unusually heavy rainfall exceeds their capacity.

In recent years, many types of nonstructural approaches to flood control have been developed which emphasize prevention of damage through the proper use of the land along a river. This concept is providing the basis for a study at UIUC which explores flood plain management through the allocation of land uses. The study attempts a comprehensive solution because it considers as a whole the upstream area — the source of the flood waters — and the downstream area — the site of the flooding. Although these areas are often far apart, they are interdependent. The amount of upstream development or urbanization increases the surface runoff from rainstorms in that area; this runoff becomes the flood waters of the downstream region.

Ideally, the goal of the UIUC study is to assign a use for each parcel of land within the affected region to minimize the possibility of flooding and damages and to maximize the value of the land. Since these factors conflict, a tradeoff is necessary between urban development, which increases land value, and runoff levels, which are increased by urbanization. Consequently, individual parcels are evaluated for a use with respect to the effect on the entire region. For example, the development of a shopping mall on an upstream site would have certain benefits for the immediate area — greater tax revenues and business receipts, among others. At the same time, the development would encourage further urbanization around it, and both would have a negative effect on flood prevention throughout the region. The paved surface areas surrounding the new commercial center would increase runoff during rainstorms. This, in turn, would increase the likelihood of flooding, causing property damage to existing residential and commercial structures in downstream areas.

Flood plain management is as complex a preventive method as the structural approach is expensive because the land area and the possibilities for its use tend to be greater. The development of a regional plan requires input from a variety of experts in many fields. The research group at UIUC includes a professor in the Institute for Environmental Studies, E. Downey Brill, Jr.; a member of the Department of Landscape Architecture, Professor Lewis D. Hopkins; and Jon C. Liebman and Harry G. Wenzel, Jr., professors in the Department of Civil Engineering.

The team has developed a computer model which enables it to assign uses to land parcels and to compare the ability of different land use patterns to control flooding and subsequent damage. Data based on the Hickory Creek watershed in Will County, Illinois, has been used to test the model. The 285 sq km (110 sq mi) region was divided into forty-two parcels or subbasins with eight land use categories including single family residential, rowcrop agriculture, commercial/industrial, and recreation. The test showed that the model may be a useful tool in flood control after certain improvements to it are made.

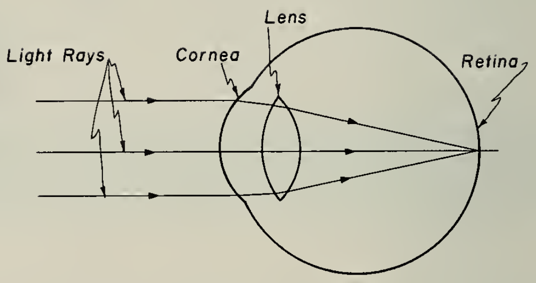
Although flood control through regional land use planning is relatively new, the development of a computer model and its subsequent testing by the UIUC team indicates that the method has potential. In fact, this and other nonstructural approaches to the problem may be the building blocks for a more secure future in flood-prone areas. ●

THE EYES HAVE IT

A UIUC engineer has a vision of the future which may not include glasses and contact lenses. Uncorrectable visual impairment ranks third, after heart disease and arthritis, among the chronic diseases restricting the ability of Americans to lead normal lives. Refractive errors, the inability of the eye to bend incoming light rays to a correct focus, are the most common cause of impaired vision. Traditionally, eyeglasses and contact lenses have been used to correct some of these refractive errors, but Professor Walter H. Olson, Department of Electrical Engineering and a member of the Bioengineering Faculty, is studying the possibility of altering the eye's corneal curvature. If his technique, now being tested on rabbit corneas, can be shown to be safe and permanent, it might make eyeglasses and contact lenses unnecessary for some patients.

The technique, called electrokeratoplasty, alters the shape of the cornea. It is being developed by Olson in collaboration with ophthalmologist Richard F. Schwerdt, clinical associate of the UIUC School of Basic Medical Sciences.

The cornea is a transparent dome of connective tissue (collagen) which covers the front of the eye. It bends incoming light so that the visual image is focused on the retina at the back of the eye. In people with good vision, the cornea, together with the eye's internal lens, acts to correctly bend incoming light. But in farsighted people the cornea may be too flat, causing the eye to focus incorrectly. People with an astigmatism have an egg-shaped cornea, which distorts visual images. Those with cataracts may need to have the lens in their eye removed because it has become clouded, obscuring vision. The normal cornea alone cannot bend the light enough to compensate for the lost lens, so thick-lensed glasses are needed. But, in all these cases, if the cornea itself could be reshaped, better vision, without the need for glasses or contact lenses, could result.



The normal eye uses the cornea and the lens to bend incoming light to a correct focus on the retina. Two UIUC researchers are studying a technique called electrokeratoplasty which can increase the curvature of the cornea. The technique may prove useful to patients whose eyes are unable to correctly focus incoming light.

Olson's technique uses electrically generated heat to increase the curvature of rabbit corneas. By placing electrodes around the outer edge of the cornea and passing a small amount of current through it, he generates just enough heat to shrink the collagen fibers which crisscross the corneal surface. This shrinkage around the outer edge of the dome-shaped cornea increases the curvature in the central untreated region needed for vision.

Olson is now conducting further tests to determine the best combination of current amplitude and duration, as well as the best shape and position of the electrodes used to generate heat. With consideration of future human applications, he is also testing the permanence and safety of the curvature change. If his continued research proves the method to be effective, permanent, and safe, the eye surgeon may someday be able to focus on getting his patient back into shape. ●

POLE FAULTING

Some researchers have to start from the ground up in their investigation of a topic. This is literally (and figuratively) the situation facing a professor in the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign.

Professor James O. Curtis and graduate assistant Donald E. Ferguson are investigating the performance aspects of support poles in pole frame buildings. While newer methods of construction (such as prefabricated units) are being used in commercial and industrial markets, pole frame construction is an older method which remains a popular way to build barns and other farm structures. It is also used to construct smaller industrial buildings where a maximum amount of floor space is needed. The name is derived from the poles which support the roof and secure the building to the ground. Poles are generally placed at intervals of 2.5 m (8 ft) around the perimeter of a barn and each pole is set 1.2 m (4 ft) into the ground.

Although the basic concept of pole frame construction has been used for over one hundred years, the technique has undergone some modifications. The most important change has occurred with the pole itself. At one time, round wood poles from trees were used as supports; the larger butt end of the tree trunk was buried in the ground for a more secure base. Today, poles are rectangular in shape because the flat surfaces make construction easier. The wood is also pressure treated to provide resistance to termites and decay.

Most pole frame structures are built by commercial contractors who secure or anchor the poles in one of three ways. In some cases, dry mix concrete is placed in the bottom of a hole, the pole is placed on the concrete mix, and the hole is filled with more dry concrete and earth. Either ground moisture or excess water is used to activate the concrete mix and to firmly anchor the pole in the ground. Other contractors substitute a precast concrete pad as a liner, retaining the concrete mix and earth as filler materials. A third method to secure the poles is sometimes used in which blocks of pressure-treated wood are added to each side of the pole's base. This procedure effectively enlarges the butt end of a rectangular pole, making it more like the natural shape of the round poles.

Curtis and Ferguson are conducting experiments to study the methods of anchoring the support poles as the poles must withstand three kinds of force. One force is the lateral load, which is the outward push from the sides or the horizontal wobble of the building. There is a downward load that is caused by snow and ice accumulations on the building's roof. And, the uplift load results from the force of wind and it acts to pull the building from the ground. The researchers are comparing the ability of the commercial anchorage methods to withstand pressure with the performance of the round wood poles when placed under the same forces.

The experiments involve a series of free-standing poles, each of which is anchored to the ground by one of the three methods. In addition, a newer method which uses polyurethane foam as a filler material is being tested. Each kind of pressure — lateral, downward, and uplift — is simulated in a different way. For example, equal amounts of downward force (the pressure of the building) are exerted on the poles by placing railroad wheels on them, one at a time. Failure of the anchorage system is indicated when the pole settles or sinks further into the ground by more than 2.5 cm (1 in.) from its original position.

Curtis and Ferguson have determined that the commercial methods perform well against downward and uplift forces. However, they are somewhat weak with respect to lateral loads, particularly when the building has an earth floor instead of a concrete floor. Consequently, Curtis is continuing the study, seeking ways to improve the resistance to lateral loads in structures without concrete floors, as many barns and other farm buildings are built with earth floors. The experiments have also enabled Curtis to provide specific recommendations to contractors concerning the design of pole frame buildings. Hopefully, the UIUC researchers' work will ensure that no farmer is left holding the short end of the pole. ●

Pole frame construction is a method that is used to build barns and other farm buildings. Researchers in the Department of Agricultural Engineering at the University of Illinois at Urbana-Champaign are testing the ability of different anchorage techniques in pole frame construction to withstand pressure. In this experiment, the downward force of the building is simulated by placing railroad wheels on the poles, one at a time.

A GIFT THAT KEEPS ON GIVING

Several programs in UIUC's Department of Civil Engineering will benefit from the newly-created Paul F. Kent Memorial Fund, honoring a UIUC alumnus, the late Paul F. Kent of Champaign, Illinois. The gift represents the assets of the General Paving Foundation which was established by Kent to provide support for educational and research programs during his lifetime. The assets were recently donated to the University of Illinois Foundation at the request of Mrs. Kent and her children. The gift will support undergraduate, graduate, and faculty programs in the areas of pavements and transportation engineering. These programs include the

C. C. Wiley Traveling Award, the Paul F. Kent Traveling Award, and the Paul F. Kent Research Assistantships.

Throughout his professional career, Kent repeatedly expressed high regard for the education that he received at UIUC. The generosity of the Kent family enables key programs to be continued which contribute to the quality of education at UIUC. ●

PEOPLE AND PLACES

The American Association for the Advancement of Science has awarded fellowships to three UIUC engineering professors: Ven Te Chow, Department of Civil Engineering; **Harry G. Drickamer,** Department of Chemical Engineering; and **David Pines,** Department of Physics. AAAS fellowships are given to persons "who have produced a body of work on behalf of the advancement of science that is scientifically distinguished or socially highly significant or both."

UIUC physics professor **Michael Wortis** has been awarded a Fulbright-Hays scholarship for study in Pakistan. The awards were made by the Board of Foreign Scholarships of the U.S. State Department.

Professor **Floyd Dunn,** UIUC Department of Electrical Engineering, has been elected to a three-year term on the council of the Acoustical Society of America. He has been a member of the UIUC faculty since 1956, working in bioacoustics, bioengineering, and biophysics.

A John Simon Guggenheim Memorial Foundation fellowship has been awarded to Professor **William L. McMillan** of the Department of Physics.

Wendell S. Williams, UIUC professor of physics, ceramic engineering, and bioengineering, has been named head of the Metallurgy and Materials Section of the National Science Foundation. He will supervise the work of program directors in metallurgy, ceramics, and polymers, and administer a $15 million research grant budget in those areas. Because of the appointment, he has taken a one-year leave of absence from the University.

UIUC aeronautical and astronautical engineering professor **John E. Prussing** has been named a senior member of the American Astronautical Society. This honors him as a member with more than 10 years' experience who has a recognized standing in the field of astronautics. He was also elevated to the grade of associate fellow in the American Institute of Aeronautics and Astronautics. ●

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COLLEGE OF ENGINEERING
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inside outlook:

ATMOSPHERIC WIND MEASUREMENT
WHEELCHAIR SLING SEAT DESIGN
SUMMARY OF ENGINEERING RESEARCH 1977
FLAMMABILITY LIMITS OF PREMIXED GASES
DRAG-REDUCING ADDITIVES IN WATER

BORNE FREE

Every woodsman knows that holding a wet finger in the air is a sure way to tell which way the wind is blowing. Nonetheless, this technique has its limitations, especially when a scientist wants to measure the winds in the outer regions of the earth's atmosphere. Instead of a wet finger, the scientist must use a more indirect and complicated method to study these winds.

Meteors (falling stars) provide the scientist with a way to estimate the speed of winds in the upper atmosphere or ionosphere. When a meteor enters the atmosphere some 90 km (56 mi) above the earth, it burns and disintegrates, leaving a trail of ionized molecules. The meteor trail — called the "meteor air" — floats in the atmosphere and moves with the surrounding winds. By measuring the speed of the meteor trail, the scientist gains a good approximation of the speed of the winds that carry the trail. The technique is similar to clocking the movement of a leaf on the water to determine the speed of a river current.

Scientists are able to study meteor trails because they reflect radar signals which are sent into the ionosphere from transmitting antenna arrays at meteor radar stations on earth. When a signal intercepts a trail, its echo is reflected back to earth and is recorded by a receiving antenna array at the same station. The speed of the meteor trail is based on the difference in frequency between the outgoing radar signal and the incoming reflection or echo. It is the same principle that describes the noise from a locomotive in which the sound and the frequency of the soundwaves increase as the train approaches the station. In a similar manner, a reflected signal returns to earth at a greater frequency when the meteor trail is moving towards the station. And, the frequency of a reflected signal is lower than the frequency of the original signal when the trail is being carried away from the station by the ionospheric winds.

At the University of Illinois at Urbana-Champaign, Professor S. A. Bowhill of the Department of Electrical Engineering and graduate assistant Richard Klein are studying the winds in the upper atmosphere through the observation of meteor trails. While this work is being conducted by many scientists around the world, Bowhill and Klein have a distinct advantage because the meteor radar station at UIUC is the most powerful one in the world. Its high echo rate means that the researchers obtain and analyze a greater number of meteor observations. Since a meteor trail lasts only a few seconds, the expanded capability of the UIUC station allows the researchers to make more accurate measurements of the ionospheric winds.

Bowhill and Klein are able to determine the location of the winds as well as their speed. This is done by recording a reflected signal on four receiving antennas at slightly different times. On-line computer analysis provides the researchers with processed data almost instantaneously. Computer analysis is particularly important in this research because the difference in frequency between a radar signal and its reflection is very small. For example, an echo from a radar signal that is sent at 41 MHz (the signal oscillates 41,000,000 times per second) returns with a frequency which is just a few dozen cycles above or below 41 MHz, depending on the direction of the meteor trail.

The researchers hope that their work will provide information on the movement of ionospheric winds and their effects on conditions at the earth's surface. Since thousands of meteors enter the earth's atmosphere every minute, meteor trails remain the best way to study these winds. For Bowhill and Klein, there should be plenty of happy trails ahead of them. ●

A PAIN KILLER WITH A SOFT TOUCH

It is comforting to realize that wheelchairs provide the physically disabled person with a means of mobility. At the same time, it is discomforting to learn that many wheelchair users suffer severe sores on their buttocks from sitting in the chairs.

Wheelchair sores are called decubitus ulcers which literally means sitting ulcers. Because some handicapped persons are unable to shift their body position in the chair, their buttocks experience constant pressure from the weight of the body against the seat. Over time, blood circulation diminishes and the tissues die. The condition is a similar but more serious version of the red spots that form when a person leans an elbow on a desktop.

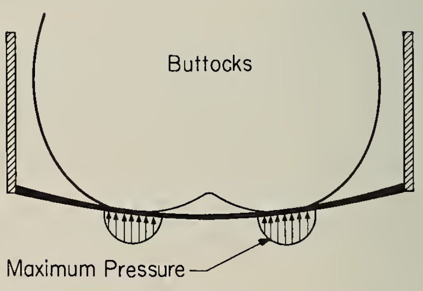
Professor William Chow of the Department of General Engineering at the University of Illinois at Urbana-Champaign has spent several years investigating the problem of decubitus ulcers. Medical analysis indicates that certain factors contribute to the development of wheelchair sores. One factor is the physical condition of the person, as measured by his age, nutritional habits, and state of health. Heat and moisture in the area of the buttocks can aggravate the problem as well. The presence of bacteria on the surface of the buttocks is an additional factor which prompts the development of sores.

While these factors contribute to the condition, Chow and a departmental colleague, Professor Eugene I. Odell, have concentrated on the role of the wheelchair seat in causing the ailment. Wheelchairs have a sling seat of stiff canvas and vinyl which is supported at the sides, like a director's chair. When a person sits in a wheelchair, the interaction of his body weight and the seat creates a high pressure contact point on each buttock. In other words, the pressure is unevenly distributed and friction tends to be greatest where the pressure is highest. Chow and Odell have found that pressure is concentrated in a small area on each buttock with a peak pressure of 24 kPa (3.5 psi) at each contact point.

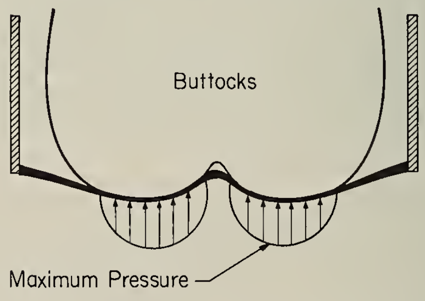
Since the ulcers are caused, in part, by the pressure and friction from the sling seat, the researchers felt that a better seat design would help to control the problem. Specifically, a new seat should be designed to exert a lower peak pressure and to distribute the pressure as evenly as possible. Using the finite element method of analysis, Chow and Odell mathematically divided the sling seat into small sections to examine the forces on each section when weight is applied. The analysis enabled the researchers to recommend a variation of the basic sling seat design in which the seat is supple instead of stiff. This feature allows the buttocks to sink into the seat, effectively increasing the contact area. Peak pressure is reduced to 10 kPa (1.5 psi) because it is distributed over a larger area on each buttock.

The new design for a wheelchair seat should not be interpreted as a way to cure decubitus ulcers because other factors cause the problem as well. Nonetheless, the analysis indicates that the formation of ulcers can be controlled through better seat design. Chow and Odell plan improvements to their seat, but the researchers have already made progress in getting to the bottom of a discomforting problem. ●

Present Wheelchair Seat



Desired Sling Seat Solution



The sling seat on a wheelchair creates a high pressure contact point on each buttock as the patient sits in the chair. The pressure and the resulting friction between the buttocks and the seat often leads to the development of open sores or ulcers. Two professors at the University of Illinois at Urbana-Champaign have proposed a new seat design (lower illustration) which reduces the pressure on the buttocks and helps to control the ulcers.

SUMMARY TIME AND THE READING IS EASY

The *Summary of Engineering Research 1977* has recently been published and is available upon request. The *Summary* reports on research conducted in the College of Engineering at the University of Illinois at Urbana-Champaign during 1976 by describing each of the more than 600 projects supported by a $19.8 million research program. Faculty publications, technical reports, and theses are also listed.

Copies of this annual publication may be obtained from the Engineering Publications Office, 112 Engineering Hall, University of Illinois, Urbana, Illinois 61801. ●

LIGHT FLAMES

Mention flames to UIUC Professor Roger A. Strehlow and his eyes are likely to light up. A member of the Department of Aeronautical and Astronautical Engineering, Strehlow is currently studying a special type of flame for the National Aeronautics and Space Administration (NASA).

The most common type of flame is produced by burning a solid fuel (such as wood) in air. NASA and Strehlow, however, are concerned with premixed flames. These are flames which are created by burning a mixture of gas and air, like the flame from a Bunsen burner. While most mixtures of gas and air are combustible, a mixture ignites and flames more readily when the percentage or concentration of gas in it is at an optimal level.

Because gas emissions are common in industrial and laboratory environments, flammability limits are used to guard against gas buildups which could trigger accidental combustion. Flammability limits are percentage figures which describe the range of composition for a mixture of gas and air over which combustion can occur. For example, a lean flammability limit is characterized by a low concentration of gas in the mixture, while a rich flammability limit is distinguished by too much gas. In both instances, the premixed flame burns slowly and inefficiently. Between these limits is an optimal concentration of gas in the mixture where the possibility of combustion is greatest and the premixed flame burns efficiently.

The goal of Strehlow's research is to generate preliminary data which will enable NASA technicians to set limits for gas emissions in a zero gravity (weightlessness) environment. Flammability limits which have been established for conditions at the earth's surface cannot be used in spacecraft such as an orbiting laboratory. These limits are affected by the force of gravity on earth, while flammability limits for use in space would not be affected. Consequently, a major part of the research is to determine the effects of gravity on the behavior of premixed flames. Experiments show that gravity significantly influences the shape and burning velocity of premixed flames moving at opposite directions in vertical tubes. In view of these developments at the earth's surface, it is likely that the differences in combustion and flammability limits in a gravity-free environment are considerable.

For any scientist, the ideal research situation is to study the subject in the appropriate environment. Strehlow cannot pursue the project in this fashion because it is difficult to create a zero gravity condition on earth. To obtain favorable conditions, Strehlow is investigating the feasibility of conducting flammability studies aboard a spacecraft. This is a complex aspect of the project in itself, involving safety considerations for the scientists and space vehicle and modifications of sensitive equipment for use in space.

Strehlow's project exemplifies the need for basic research before a problem can be solved. In a sense, the work at UIUC is sparking the prevention of accidental combustion in a down-to-earth manner. ●

SOUPED-UP WATER

How do you like your water — hot or cold, hard or soft, fresh or salty, iced or tap, calm or choppy? Perhaps you prefer faster water? This addition to the list of watery adjectives describes a type of water that is being investigated at the University of Illinois at Urbana-Champaign.

Professor Wilbert F. Stoecker of the Department of Mechanical and Industrial Engineering is working to perfect faster water by adding a liquid polymer (a soupy substance) to the water. The polymer eases the friction or drag between the water and the pipes in closed water systems, such as the systems used to heat and cool office buildings. The drag-reducing substance is added to achieve one of two effects. It can be used to maintain a constant flow of water in the system after the pressure from the pump has been reduced. Or, the polymer can be added to cause more water to flow through the system without an increase in pump pressure.

Stoecker is particularly interested in the use of the polymers to achieve the second effect. Experiments are being conducted in a small-scale closed water system at UIUC's Mechanical Engineering Laboratory. Specially treated water is circulated through a maze of pipes and heat exchangers to gauge the effect of the additive on both the pressure drop and the heat transfer coefficient. Initially, the drop in pressure along the pipeline is minimized with the addition of the drag-reducing substance. Stoecker has found, however, that the polymer loses its effectiveness after six to ten hours in closed water systems where the water is constantly recirculated. Nonetheless, it is possible that the additive can be used on a short-term basis — at times of peak demand for air conditioning, for example — since the additive does not appear to negatively affect the heat-transferring ability of the specially treated water.

Drag-reducing additives have already been developed for use in open water systems where the same water is not recirculated. In one application of the technology, fire departments substitute less awkward and lighter water hoses for larger and heavier hoses. The smaller (in diameter) hoses deliver the same amount of water as the larger hoses because the additive causes the water to flow faster.

Use of drag-reducing polymers effectively increases the circulation capacity of a closed water system without physical expansion of the system. It should prove to be beneficial in office buildings where the heating and cooling systems become strained on hot and cold days. And, use of drag-reducing polymers in closed water systems conserves energy because more water is exchanged at the same pressure. Although the polymer remains to be perfected for general application, Stoecker's research should put faster water into circulation quicker. ●

PEOPLE AND PLACES

Dr. **Rosalyn Sussman Yalow,** the second woman to earn a doctorate in physics from UIUC, shares the 1977 Nobel Prize in medicine. The award was made for her pioneering work in endocrinology. She is the fourth UIUC physics alumnus to share a Nobel Prize.

Professor of environmental engineering **Richard S. Engelbrecht** has become president of the Water Pollution Control Federation, an international technical organization engaged in the design, construction, operation, and management of water pollution control facilities.

The Physics Building at UIUC has been renamed the **Loomis Laboratory of Physics** in honor of Professor F. Wheeler Loomis, head of the physics department from 1929 to 1957. Professor Loomis retired in 1959 and died in 1976 at the age of 86.

Benjamin A. Jones, Jr., UIUC professor of agricultural engineering, has received the 1977 Hancor Soil and Water Engineering Award of the American Society of Agricultural Engineers.

The American Institute of Aeronautics and Astronautics has elected professor **Herman Krier,** UIUC Department of Aeronautical and Astronautical Engineering, as chairman of its Propellants and Combustion Technical Committee. He will serve a three-year term.

John Bardeen, emeritus professor of electrical engineering and of physics, has been awarded an honorary Doctor of Science degree by the University of Cambridge, England.

Professor of physical metallurgy **David S. Lieberman** has been named a Sigma Xi National Lecturer for 1977-78 and 1978-79. Sigma Xi chooses a group of outstanding scientists who are then available for speaking engagements to discuss "particularly lively areas of current research in a manner appropriate for interdisciplinary audiences." ●

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inside outlook:

INFRARED SOURCE AND DETECTOR RESEARCH
DISTRIBUTED PARAMETER MODELING OF HUMAN TORSO
ELECTRON MICROSCOPY AND METAL MICROSTRUCTURE
COMPARATIVE COAL TRANSPORTATION COSTS

MANY HANDS MAKE LIGHT WORK

To the rapidly developing field of fiber optics, light has taken on a special meaning because light can be used to transmit information through long silica fibers. Any information to be communicated long distances, e.g., telephone, television broadcasting, and computer data, may soon be transmitted through these hair-thin optical fibers. Fiber optics transmission is a less expensive and more efficient means of sending information than the systems now used, but this new method requires the same three components which make up all communication systems — a source, a receiver, and a connection between the two. Adequate optical fibers already exist as a connection, but good light sources and receivers are still in the developmental stage. At the University of Illinois at Urbana-Champaign, two teams of engineers are working on the development of effective infrared light sources and receivers.

Infrared light is well-suited to optical information transmission because its longer wavelength makes it less susceptible to the twin bugaboos of fiber optics transmission — signal dispersion along the fiber and signal absorption by the fiber. But before infrared light can be used commercially, effective solid-state laser devices to use as a light source and effective infrared detectors to change the light signal into an electrical one must be devised.

The heart of the source and detector research at UIUC involves the same material: a quaternary compound known as indium gallium phosphide arsenide. Pioneering work on the compound was done at UIUC by electrical engineering professor N. Holonyak, Jr., and now researchers here have developed a new and relatively inexpensive way to grow the compound in successive crystal layers. Their method, besides being less expensive, has the added advantage of making the crystal layers extremely thin. The compound's properties, especially in thin layers, makes it potentially useful as both a light source and a light detector.

Light can be generated by a photodiode, a device which controls the interaction of electrically generated electrons and holes (positive current carriers). When the electrons encounter the holes, they attempt to annihilate them; the upshot of this is the emission of photons, or light. This process puts the glow in digital watches and hand-held calculators, but it can also be used to generate light for fiber optics transmission.

A device that can emit coherent infrared light is being investigated by Holonyak and his graduate students. The device would use the properties of the multiple layers of the quaternary compound in a synthetic crystal that emits light. The potential usefulness of the device is enhanced by the thinness of the crystal layers. These layers restrict electron movement; the restriction means that the electron goes into higher and higher energy states and emits higher energy photons. The ability of the synthetic crystal, in thin layers, to provide a range of energy states gives Holonyak a new freedom in the design of a light source device. It also means that there is less internal absorption of the photons by the device, making it a potentially more efficient light source. These properties of the quaternary compound make it possible to build a device which emits high frequency light signals with little absorption, signals ideally suited for fiber optics transmission.

The development of more effective infrared detectors is being pursued by Professor G. E. Stillman, also of the Department of Electrical Engineering, and his graduate students. The ideal optical signal receiver would require minimum optical input to generate adequate electrical output. A particular type of detector called an avalanche photodiode is well-suited to this task, because it multiplies the electrons and holes generated by light, and thus produces larger electric current output. Unfortunately, this multiplication process (or gain) also increases the noise in the signal as well as increasing the signal itself. Noise is unwanted fluctuations in the signal which distort or cause a loss of the information it carries. Minimizing this increased noise while maximizing the increased signal current requires the investigation of the specific properties of the quaternary compound used in the avalanche photodiode. These properties, when understood, will permit the optimum design of the basic structure of the detector. Stillman's research on the quaternary compound may enable him to construct a low noise, high gain avalanche photodiode which would be an efficient, effective infrared detector.

In effect this research is a harnessing of the basic components of light and electrical current to make an effective communications system. By controlling the transformation of an electrical signal into a light signal, and a light signal back into an electrical one, communication via infrared light is a real possibility. With continuing research, someday infrared light may be the "light that succeeds" in clearly and effectively sharing information. ●

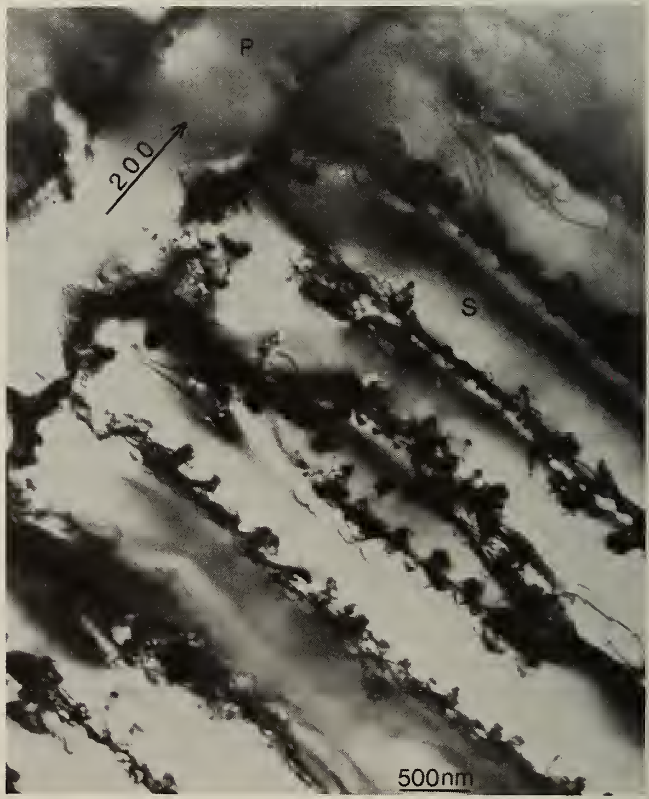
LIKE A TORSO ONLY MORE SO

"Ouch!" is the way most people would describe whiplash, the result of head-snapping, spine-jarring collisions. But two UIUC engineers are describing whiplash using a more exotic method — distributed parameter modeling — in order to develop a mathematical description of torso bending in whiplash conditions.

Human torso bending can be determined experimentally, through the use of dummies or animals similar to man, or theoretically, using mathematical equations to approximate the bending in a simplified model of the human body. Using the latter method, it is possible to describe the human torso either as a series of connected chunks (lumped parameter modeling) or as a continuous elastic beam (distributed parameter modeling). Professors L. D. Metz and W. J. Davis, UIUC Department of General Engineering, feel that the continuous elastic nature of the spine itself makes distributed parameter modeling a more realistic method of analysis, and they have developed a description of whiplash using this method.

Distributed parameter modeling involves more complex mathematics than are needed for the lumped parameter model, but Metz and Davis feel that the added complexity is worth overcoming. They characterized the human torso as a long flexible beam (the spine), clamped at its base (the hips), with a large mass on top (the head). They derived the equations governing the motion of this model, as well as other more subtle mathematical descriptions of the forces controlling its response to impact. Problems remaining have to do mainly with solving the nonlinear partial differential equation of motion in the model, and determining the physical characteristics of human tissue.

Determining the relationship between the amount of torso bending and whiplash injury requires information from humans, but the human whiplash data are sparse. Since it is highly unlikely that people will volunteer to contract whiplash under controlled conditions, the Metz and Davis model can be used mainly as a step forward in analyzing the bending response of the human torso to large jolts. ●



Rapidly cooled alloy powder shows a characteristic precipitation, visible in this photograph as dark nubby bonds. This powder is used in making turbine blades, and the knowledge of its microstructure gained through UIUC professor Hamish Fraser's use of scanning transmission electron microscopy is vital to maintaining blade quality. The marker at the bottom is less than 1000 atoms long.

STEM BLOSSOMS

Until recently, knowledge of metal microstructure was locked inside the metal itself. However, advanced technology depends more and more on understanding and being able to measure the components of metals, because today metals are being used in new and different ways.

Building such diverse items as turbine blades, solar cells, and semiconductors requires precise knowledge of the chemistry and structure of the materials used in them, since impurities at the atomic level can impair their performance.

Professor Hamish Fraser, of the UIUC Department of Metallurgy and Mining Engineering, is using a technique called analytical electron microscopy to "look through" metals, unlocking this knowledge of metal structure and chemistry. By using a scanning transmission electron microscope (STEM), he is now able to examine metals on nearly an atomic scale, the level which determines a metal's properties.

The electron microscope sends a beam of electrons called a probe into a thin piece of metal; this metal or "foil" is a layer only a few hundred atoms thick. What happens when the electron beam strikes the foil allows both the physical and chemical characteristics of the metal to be analyzed. Photographs can be made using the electron microscope, so that Fraser can examine clusters of only a few hundred atoms. Chemical structure can also be analyzed using STEM, because of the interaction of the atoms in the metal with the electrons in the probe.

Every chemical element has a characteristic atomic structure, which means each responds differently to the electron beam. This difference in the element's response allows analysis of microstructure using two techniques — x-ray spectroscopy and electron-loss spectroscopy. Some of the x-rays emitted by the element after electron bombardment are characteristic of that element, and can be measured to determine the metal's chemistry. However, certain elements cannot be measured using x-ray spectroscopy; the examination of elements like carbon, oxygen, and nitrogen requires the use of electron-loss spectroscopy. Since the probe loses different amounts of energy when it hits these atoms, the electron loss can be measured to indicate the presence and concentrations of these elements.

The ability to analyze metal microstructure has wide applicability. The information STEM gives is useful to fields as diverse as solid state physics, metallurgy, ceramics, electrical engineering, chemistry, and the biological sciences. Fraser's laboratory will soon acquire a new and better STEM, a VG HB5, one of only two such devices in the nation. It has the added advantages of a higher brightness probe, an energy-loss spectrometer, and an ultrahigh vacuum around the foil, which decreases contamination.

Fraser's research is already proving its usefulness to today's technology. Advance turbine blades need to be tough so that they can withstand the extreme environment in which they are used. A superior blade can be made using a metal powder formed by rapid cooling, but the chemical structure of this powder must be rigidly controlled if the blade is to last. Without the STEM technique, the structure of this rapidly cooled powder would be anybody's guess, but with STEM, the chemical makeup of the powder can be easily determined.

STEM finds other applications in cases which require a precise knowledge of the microstructure of the material involved. Solar cells, which convert the sun's rays to electrical energy, require the use of chemically stable materials. Semiconductors, such as the ubiquitous transistor, depend on the chemical purity of their elements for their electrical properties. Again, STEM can be used to determine the chemical makeup of the materials used in these devices, ensuring good performance. No doubt other important uses like these can stem from the application of Fraser's probing research. ●

COAL CASH

Carrying coals to Newcastle is a classic waste of time. But *how* those coals are carried can also be a waste of money, especially today when their destination is not Newcastle, but the distant power plant where they are to be used. There are a number of ways to transport coal from the mine to the consumer, and today's increasing energy costs mean that the comparative costs of each transportation method is a crucial question. Two UIUC faculty members have compared the cost of various methods of coal transportation in the United States, and have come up with information important to pending energy legislation.

Traditionally, coal trains and river barges have been used to move coal over long distances. Another method uses a coal slurry pipeline, but only one such pipeline is active today. The coal slurry method transports a half-and-half mixture of pulverized coal and water through a pipeline from the mine to the receiving station, where the slurry is then "de-watered," leaving only the pulverized coal.

A coal slurry pipeline stretching from Wyoming to Arkansas has been proposed, and Congress will soon decide whether eminent domain rights will be granted so that such a system can be built. But the results of a comparative cost study, done by Professors Shao Lee Soo, Department of Mechanical and Industrial Engineering, and Michael Rieber, Center for Advanced Computation, indicate that building such a system may not be worthwhile. After determining the components of each transportation system, examining coal industry data, and comparing costs for comparable time periods, they conclude that, in this case, rail transportation is probably the cheapest long-distance coalmoving method.

Railway shipment can be the least expensive because railroad tracks already exist, and even if the tracks need to be expensively upgraded, the cost is still less than that of building a new coal slurry pipeline. River travel is cheaper than rail travel, but adequate rivers are not always handily placed between the producer and the consumer, which means additional gathering, distribution, and storage costs. The UIUC researchers' findings, showing that upgraded railroad transportation is cheaper in this case than building a new pipeline, will be released by the Bureau of Mines and the Federal Energy Administration, and will be important to upcoming energy legislation. As coal plays an ever-increasing role in our energy future, Rieber and Soo are ensuring that efforts to transport it stay on the right track. ●

PEOPLE AND PLACES

Professor of aeronautical and astronautical engineering **Allen I. Ormsbee** has been named head of the Aviation Research Laboratory in the Institute of Aviation at the University of Illinois at Urbana-Champaign.

Professor of metallurgical engineering **C. M. Wayman** has been elected a fellow of the American Society for Metals. He is cited for "experimental results and publications leading to improved understanding of phase transformations."

The Institute of Electrical and Electronics Engineers has elected Professor **James N. Snyder**, head of the Department of Computer Science, as a senior member, the highest professional grade for which application may be made.

Harry G. Wenzel, of UIUC's Department of Civil Engineering, has been awarded a Walter L. Huber Civil Engineering Research Prize by the American Society of Civil Engineers. He is one of five national winners. ●

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inside outlook:

1978 ENGINEERING OPEN HOUSE
HUMAN-COMPUTER INTERACTION
WASTEWATER TREATMENT IN JAPAN
METAL FORMATION VIA RHEOCASTING

ENGINEERING: SPEARHEAD OF PROGRESS

The theme for the 1978 UIUC Engineering Open House, to be held March 3 and 4, is "Engineering: Spearhead of Progress." The annual student-run event is sponsored by Engineering Council.

Each year EOH brings thousands of visitors to the campus to see all phases of the College of Engineering in action. The exhibits, which display scientific principles, engineering of those principles, and current research, are of particular interest to high school students interested in the opportunities engineering offers as a career.

In conjunction with the open house, SITE (Student Introduction to Engineering) will conduct its two-day program for high school juniors and seniors.

Everyone interested in engineering is invited to attend; for more information contact 300 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801. ●

HUMAN AND COMPUTER: THE DYNAMIC DUO

Decision making, the process of analyzing what's going on and what can be done about it, is now within a computer's powers. In fact, computers are increasingly being used in a number of complex decision-making situations. Already commercial aircraft can be flown using only a computer as pilot, and computers also play an important role in industrial process monitoring, in diagnosing system failures, and in management decision-making situations. This increased range of computer functioning raises the important question of exactly what role the human will play as systems become automated. Is his job now obsolete; will he become merely a machine tender? Will the work be divided in such a way that the human only has responsibility for those tasks which the computer cannot as yet do? Or is there a way that the work can be shared so that the human remains actively involved, and thereby offers to the system his versatility and ability to deal with unforeseen situations?

The potentials for active, flexible interaction between human and computer are being studied by Professor William B. Rouse, of the UIUC Department of Mechanical and Industrial Engineering and the Coordinated Science Laboratory. He is studying the ways in which humans and computers can work together in order to design a system which involves the human while making use of computer technology. This effort requires an understanding of how people make decisions, and how they can work with computers to make the best use of their respective abilities.

Rouse is examining these issues in three settings. The first is multiple-task situations, such as piloting an aircraft or monitoring industrial processes. These situations require simultaneous attention to a number of ongoing processes, and fast and efficient communication between man and machine. A pilot must keep vigilant watch over the mechanical and electrical subsystems of his aircraft (such as fuel, hydraulics, and engine) while keeping the plane on a prescribed course. Computers can be used to do many of these functions, but should they all be fully automated, with the human acting merely as a caretaker?

The second setting, fault diagnosis, involves the detection of failures in complex processes such as those found in nuclear reactors. The computer is able to monitor the functioning of such complex systems, but the human is needed if something goes wrong. This requires trained individuals who can read the symptoms generated by the computer, and make decisions accordingly. How can this kind of accurate and effective response be assured?

In another setting, computers are often used in management situations to generate information about operations. An example is the Illinois Library and Information Network (ILLINET), which is slowly becoming automated. Can people in ILLINET make the best use of the management information that the computer makes available?

Answering these questions requires selecting the essentials of the decision-making processes in each case and studying how they can be interfaced. In multiple-task situations, Rouse feels that a dynamic allocation of responsibility, where both human and computer share responsibility for many of the tasks, is the best mode of human-computer interaction. With dynamic allocation, responsibility for performing the task would go to the decision maker who has the time to do it well. Supported by NASA, Rouse and his colleagues are studying various aspects of dynamic allocation in a laboratory setting, using simulation of aircraft piloting and industrial process monitoring to develop a model of human decision making in these settings. Using a combination of control theory, queueing theory, and pattern recognition methods, the researchers have developed a model of how a person detects events and then allocates his attention to take possible diagnostic action. This model makes it possible for humans and computers to communicate effectively about the actions they are taking.

In the fault diagnosis setting, information is needed about how people solve troubleshooting problems. Humans are especially good at dealing with the kind of problems that arise when an undiagnosed fault is detected in a system, and they find the job challenging and rewarding. Rouse and his colleagues are studying how people go about solving problems within a system of contingencies. The data being accumulated will help in designing a computer-aided fault diagnosis system that utilizes human flexibility.

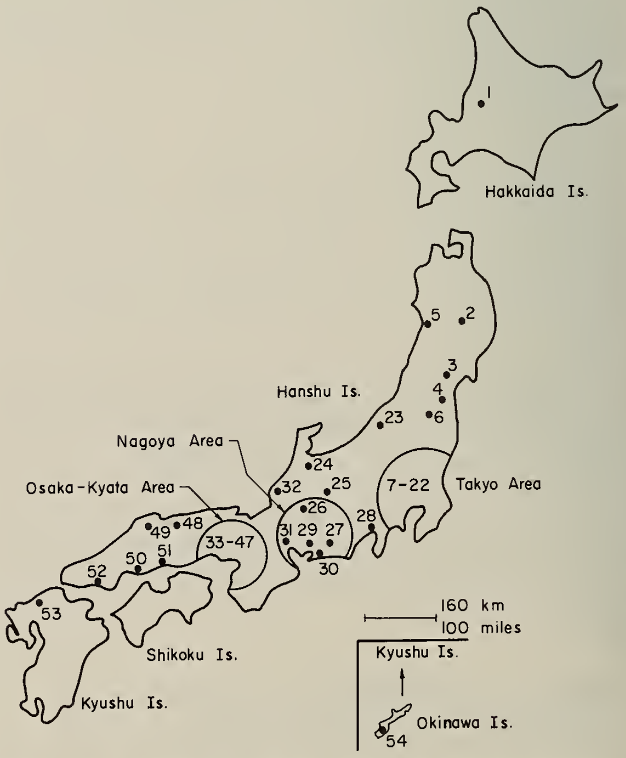
The optimal use of automation in a management system requires that the information contained in the computer be accessible and useful to the nontechnical personnel it is designed to assist. An understanding is needed of how people use the information generated by the automated system so that the best use of the computer's capabilities can be made. With support from the Illinois State Library, the investigators have developed a prototype management information system which they are using to study various mathematical and statistical information processing and human-computer interaction issues.

As automation continues to be used in decision-making situations, the effective interaction of humans and computers becomes a vitally important issue. While some may envision a day when machines take over all of man's work, others realize that people have special needs and capabilities that no machine can replace. Making the best use of these capabilities, while using the benefits automation has to offer, depends on an understanding of how humans and computers can interact in any decision-making situation. Rouse's work assures that, when people and computers work together, people can get a piece of the action while maintaining peace of mind. ●

TRICKS TO TREATING

"Cool, clear water . . ." runs the refrain of a popular song, but the water in modern societies does not run cool and clear without effective water treatment systems. The effects of rapid industrialization and dense city living on water quality is a concern shared by all rapidly developing nations, and one they are all trying to deal with. Japan, with its crowded cities, dependence on industry, and heavy use of synthetic fertilizer, serves as an example of severe water pollution and attempts to control it.

The Japanese government is undertaking a major program to provide additional sewage collection and waste-



The Japanese government has undertaken a major sewage collection and wastewater treatment program that includes 54 regional wastewater treatment systems. UIUC investigators E. Dawney Brill and Masahisa Nakamura spent six weeks in Japan studying the issues which have arisen in the Japanese project.

water treatment, and two UIUC investigators have examined the Japanese efforts. Their six-week on-site study was aimed at finding out what issues have arisen in the Japanese project, and they identified a number of factors which are potentially important to any country implementing new wastewater treatment systems.

The researchers, E. Downey Brill of the UIUC Department of Civil Engineering and the Institute for Environmental Studies, and his associate Masahisa Nakamura, were especially interested in the issues related to the planning and designing of regional wastewater treatment systems. In Japan the regional system generally includes central treatment plants serving many communities. One of the advantages of centralized plants is that they offer economy of scale — it is cheaper to build one large plant than many smaller ones.

The building of centralized treatment systems in Japan offers several other advantages. Government funding is more likely if a series of similar regional systems is proposed, because the project is more easily described and understood on a national political level. Also, regional systems can be implemented and administered more easily than can a series of local projects. This is a significant consideration in a country like Japan where water pollution is already severe. Finally, a series of similar regional systems makes better use of a limited number of technical personnel, since they are able to transfer experience from one project to another, and trained operators can be concentrated at control facilities. These factors are important advantages in any rapidly developing nation which may not have the large network of trained people needed to build and operate a diverse series of community projects.

The study also noted some potential disadvantages of highly centralized systems. For example, such systems are literally "cast in concrete" and are likely to be less flexible than decentralized systems when dealing with future needs such as water re-use. Also, any uniform national approach tends to inhibit creativity in developing unique local solutions to wastewater management.

These advantages and disadvantages are only a few of a number of factors found in the Japanese project. The researchers feel that many of the technical and social planning issues they recognized in Japan are potentially important to any country planning a regional wastewater treatment system. They feel that the identification of these factors provides additional guidance as new systems are planned in developing and industrial nations. By recognizing the array of complex issues arising in the Japanese experience, the route to cool, clear water may run smoother for similar systems in the rest of the world. ●

SLURRY WITHOUT THE FRINGE ON TOP

Since the Iron Age, man has had only two ways to shape metal — melt it or beat it. Since the Bronze Age, man has had only one way to overcome the limits of a certain metal — mix it with another metal to form an alloy. But a new metal-forming technique being investigated at the University of Illinois at Urbana-Champaign gives man another way to shape metals, as well as a way of mixing metals with nonmetals. The technique, called Rheocasting, uses agitation to create a partially solid slurry of heated metal. This thin sludge can be cheaply and effectively shaped using traditional metal-forming techniques, but it has another more exciting advantage — the slurry, unlike molten metal, easily combines with nonmetal substances.

Professor Robert Mehrabian, of the UIUC Departments of Metallurgy and Mining Engineering and Mechanical and Industrial Engineering, helped develop the Rheocasting technique. Now he and his associates professors D. G. Backman and G. J. Abbaschian are working with graduate students on the potentials it offers.

Until now, the two basic processes used to shape metals were casting and forging. Either the metal was heated until it liquified, then poured into a mold (casting), or it was softened with heat and gradually shaped (forging). A partially solid metal could not be shaped because it forms a fringelike network of solid metal (called dendrites) with liquid in between, comparable to a sopping-wet sponge. Trying to shape the partially solid metal would either squeeze out the liquid or crack the dendritic network.

But the Rheocasting process, by thoroughly mixing the solidifying metal, destroys the solid network of dendrites, yielding instead a fine slush of spherical metal particles suspended in a liquid. This slush can be shaped into useful objects as easily as if it were modeling clay. Also, the metal particles in the slurry can combine with nonmetals, creating unique metal/nonmetal composites. The dendritic network in conventionally treated metals prevents this kind of combination, but, given the right time and temperature, the spherical metal particles in the slurry will react slightly with the added nonmetals. This characteristic allows the formation of a metal/nonmetal composite, with potential advantages such as reduced resistance to abrasion and cheaper manufacturing costs.

Another advantage of the composites is that they can decrease the high energy cost of certain metals. Reducing bauxite to aluminum uses almost 4 percent of the nation's total electrical energy; Rheocasting allows other cheap, abundant nonmetals like sand, recycled glass, and incinerator ash to be combined with aluminum. These composites, if they maintain the engineering properties of the metal, can sometimes yield an energy cost savings of as much as 30 percent. Recycling these new composites is no problem, since the nonmetals can be easily separated from the metals using conventional recycling techniques. While no one expects our time to become known as "The Rheocasting Age," this new method of shaping metals which also allows metal/nonmetal combination is certainly an important technological advance. ●

PEOPLE AND PLACES

Professor **R. O. Simmons,** head of the Department of Physics, has been appointed to the editorial board of the American Physical Society journal *Physical Review B.* He will serve a three-year term.

The American Institute of Aeronautics and Astronautics has reappointed Professor **Harry H. Hilton,** head of the Department of Aeronautical and Astronautical Engineering, to its committee on structures, and Professor **John E. Prussing,** also of the department, to its committee on astrodynamics.

Professor **John E. Baerwald,** director of UIUC's Highway Traffic Safety Center, has been named a member of the technical advisory committee of the Illinois Transportation Study Commission.

Engineering Index has appointed **Martha E. Williams,** director of the UIUC Information Retrieval Research Laboratory, to its board of directors.

The American Nuclear Society has awarded the 1977 Mark Mills Award for outstanding graduate work in nuclear science and engineering to **Gino DiIorio,** who received a Ph.D. from the Nuclear Engineering Program at UIUC in October 1976. ●

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inside outlook:

- STRUCTURE AND FUNCTION OF POLYMER SYSTEMS
- NUCLEAR FUSION RESEARCH AT UIUC
- TREATING TUMORS WITH HEAT
- HOME SOLAR HEATING FURNACE

TIES THAT DON'T BIND

In the early years of polymer research, industry heeded the biblical directive to "be fruitful and multiply" by synthesizing as many different types of polymers as possible. This research, done in the 1930s and 1940s and led by UIUC graduate Wallace H. Carothers, resulted in the multitude of polymer products we depend on today. Synthetic fabrics, elastomers, plastics, structural foams, paints, and glues are only a few of the many products made from the long chain molecules known as polymers.

Today research emphasis has shifted away from synthesizing new types of polymers toward rearranging the structure of existing polymers, thus increasing their usefulness. This rearrangement is done on the microscopic, molecular level (usually during the processing stage of production) and requires an understanding of how polymer morphology (the types and spatial arrangements of structural units within the polymer) affects the way a polymer responds to deformation.

Many polymer systems are characterized by hard, relatively undeformable regions interspersed with softer, deformable regions. The soft regions can contain several different types of polymer chains: bridges (each end of the chain attached to a different hard region); cilia (only one end attached to a hard region); loops (both ends attached to the same hard region); and floating chains (completely unattached to any hard region).

Classical polymer theory holds that only bridges affect polymer deformation behavior because as the distance between the ends of a bridge change during deformation, the number of shapes (configurations) that the bridge can have changes.

But new theoretical research by Professor Richard J. Gaylord, of the Department of Metallurgy and Mining Engineering and the Materials Research Laboratory, indicates that chains, other than bridges, can also affect polymer deformation behavior. If the hard regions are viewed as forming walls which confine chains within soft regions, then a change in the distance between hard regions alters the number of configurations available to any type of polymer chain. This means that cilia, loops, and floating chains, even though their end-to-end distance need not change with deformation, can have a major influence on the properties of a number of polymer systems.

Gaylord's approach has been successful in explaining experimental results on such complex polymer systems as block copolymers, semicrystalline polymers, crosslinked polymers, and filled or reinforced elastomers, which the classical theory was unable to handle. His work also has practical importance, because it offers a new feature of polymer morphology which can be used to control the properties of many different polymer systems. Thus, it might be said that cilia, loops, and floating chains can help to "bridge" the gap between theory and practice in polymer research. ●

COMBINE AND CONQUER

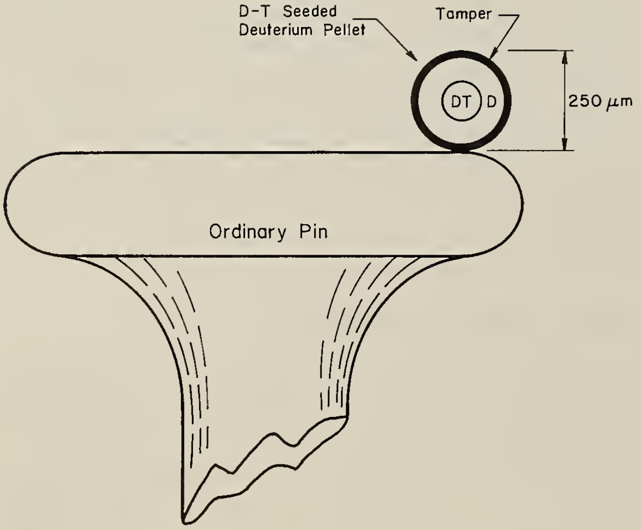
Icarus tried to touch the sun and failed, the heat proved too great for his waxen wings. Today, the untouchable sun is more within reach, because nuclear engineers may soon find a way to use fusion, as the sun does, to generate energy here on earth. Fusion reactors would combine the nuclei of light elements found in water, and they could, from a single gallon of water, generate as much energy as is now available in 300 gallons of gasoline.

Today fission reactors split the nuclei of heavy atoms to yield energy. While they seem essential to fill the near-term gap in energy supply, uranium reserves are limited and eventually other energy sources must be employed. One of the most attractive is fusion, which can use an element like deuterium, an isotope of hydrogen abundant in water, as one of its major fuels, making it a truly "inexhaustible" energy source.

Among the fuels being considered for fusion reactors are deuterium-tritium (D-T), deuterium-deuterium (D-D), deuterium-helium (D-^{3}He), deuterium-lithium (D-^{6}Li), and proton-boron-11 (p-^{11}B). These fuels require extremely high temperatures to fuse, temperatures so high that the related engineering problems are comparable to those involved in containing and using the energy of a small sun.

Of these potential fuels, D-T requires the lowest temperature for fusion. Research and development projections predict that suitable methods for D-T fusion will be available in the 1980s, and functioning plants will be possible by the turn of the century. But the other fuels, called advanced fuels, offer important advantages over D-T, in spite of their higher fusion temperature requirements.

D-T requires the breeding of tritium, which must be contained and stored, while the advanced fuels do not, which greatly simplifies reactor design. Also, advanced fuels like D-D create a greater percentage of their energy via charged particles, which means that they offer the potential for direct energy conversion. By coupling directly to charged particle energy through the use of electromagnetic fields, the efficiency of the conversion of thermal energy to electrical energy would be increased. Because of these advantages, the UIUC team feels that these advanced fuels should be considered as important and exciting alternatives to the D-T fusion possibilities.



A tiny fuel pellet which could be used in fusion reactors is being investigated by a UIUC team of nuclear engineers. It is made up of a layer of deuterium which surrounds a deuterium-tritium core. Because of its lower fusion temperature, the D-T seed would ignite the outer deuterium layer when a high energy-ion beam is trained on the pellet.

UIUC nuclear engineering professors George Miley, Chan Choi, and John Gilligan, together with eight research assistants, are investigating the potentials offered by advanced fuel fusion. Their research centers on the need to confine the hot ionized gas, called plasma, and involves two separate approaches. They are considering magnetic confinement — the use of magnetic devices to contain the plasma, and inertial confinement — the use of micron-sized pellets as fuel for the fusion reaction.

Magnetic confinement involves the engineering of plasma confinement devices which can operate at the extremely high temperatures needed for fusion. They are considering the use of stoppered mirror devices, such as field-reverse mirrors, tandem mirrors, or a bumpy torus, which confine the plamsa through the use of magnetic fields. A "mirror" device is often likened to a magnetic bottle because, like a bottle, the plasma is contained in the main portion of the field but leaks out the ends. "Stoppering" means the use of auxiliary magnetic fields to reduce this leakage.

The inertial confinement they propose makes use of a layered pellet of advanced fuel, with a core of D-T at its center. This D-T seed, because of its lower burning temperature, would exert a match head effect to light the outer advanced fuel layers. Ignition would be caused by a high-energy ion beam trained on the tiny fuel pellet, which would fuse before it could fly apart. Thus confinement, due to the inertia of the individual atoms in the pellet, is achieved. The scale of the pellet is tiny; the UIUC workers point out that one can be placed in the eye of a sewing needle. Yet the energy gained from "burning" several pellets a minute is sufficient to fuel a standard 1000-megawatt plant.

Another advantage of advanced fuel fusion is that, once implemented, it could use large central plants with a series of smaller, satellite plants. One suggestion is that D-T seeded pellets would generate ^{3}He in a central plant, which could then be transported as fuel to satellite plants, which would make use of the "stoppered mirror" concept and would be almost radiation free. The potential for flexible placement of smaller plants on the urban sites where they are needed is a distinct advantage of this approach.

Though advanced fuel fusion offers the potential for safe, clean, limitless, and efficient energy production, the potential cannot be realized overnight. This two-year project, which is funded by the Electric Power Research Institute, involves the UIUC team as well as several other laboratories, and it is only a beginning. Research and development of reactors and converters, as well as devices to burn and contain the fuels, are needed before advanced fuel fusion, alone or combined with D-T fusion, becomes a reality. It is anticipated that once the technology becomes available, advanced fuel fusion is achievable almost simultaneously with D-T fusion. As research continues, the possibilities increase that someday nuclear reactors, using fusion and advanced fuels, will be able to combine, not divide nuclei, and conquer our increasing energy needs. ●

TOPICAL HEAT WAVES

Treating cancerous tumors with heat is not a new idea. In the 1890s some physicians used bacteria to induce high fevers in their patients — those patients lucky enough to survive the illness often showed tumor regression. Today there are less debilitating ways to use heat to treat cancer, and UIUC investigators are studying several methods of tumor heating, hoping to develop techniques which can eventually be used for therapeutic treatment.

Ultrasound (acoustic signals with a frequency above the range of human hearing) and microwaves (high-frequency radio waves) can both be used to heat tissue from the inside. Food cooks quickly in microwave ovens because the food itself is heated, not the air around it, as in traditional ovens. Charles A. Cain, assistant professor of electrical engineering and of bioengineering, and his colleagues are researching the potential of ultrasound and microwaves for cancer tumor treatment by examining their effects on cell function, and designing effective applicator techniques.

Biologists still do not know exactly why heat can delay tumor growth or cause tumor regression. One suggestion is that heat increases the cancer cell's immune characteristics. This is based on a theory that cancer cells show up spontaneously in the normal human body, but that the body's immune system can recognize them as alien and render them harmless. Perhaps some cancer cells are able to mask their "alienness," disguising themselves from the immune system. Such cells might then proliferate into tumors. Heat may act to increase the alien characteristics of the cell so that the immune system recognizes them as cancer cells and handles them accordingly. Testing this hypothesis requires an interdisciplinary research effort, and Cain has been working on these problems with Gerald E. Piontek, postdoctoral trainee from the Radiation Oncology Training Program, and Wayne A. Tompkins, an immunologist from UIUC's School of Veterinary Medicine.

Cain and his colleagues are comparing the effect of a variety of heating techniques on tumor growth. It seems that any method of inducing heat can lead to tumor regression, but there is a possibility that ultrasound and microwaves have beneficial effects unrelated to their ability to induce heat. Thus, the nonthermal effects of the waves on cell function are also being examined.

In addition, work is being done on the design of effective applicator systems. The goal is to design an applicator which will maintain the tumor at a constant temperature of approximately 44°C (normal body temperature is 37°C) without appreciably heating the normal tissue surrounding it. Directing microwave radiation into the tumor requires the use of special antennas. Ultrasound is more easily focused because of its smaller wavelength in tissue, but the design of applicators for both kinds of nonionizing radiation presents interesting engineering problems that are being investigated.

The ultimate goal of this interdisciplinary effort is the development of treatment techniques, using ultrasound and microwaves, which can be used clinically to treat cancerous tumors. Though much more work needs to be done, the UIUC effort represents a hot new wave in cancer research. ●

HOMEMADE HOUSEWARMING

Using the sun's energy to heat buildings is certainly one of those ideas whose time has come, but for the most part, available solar heating devices are experimental and expensive. But a UIUC engineer is designing a solar heating furnace that may prove to be both inexpensive and effective, as well as being easy to build. If the device can be developed, it may allow the individual homeowner to "do it himself," by making his own solar heating furnace to keep home temperatures up and costs down.

Professor F. G. Bauling, of the Department of Theoretical and Applied Mechanics, is designing a flat plate solar collector that does not use high-cost mirrors or lenses to concentrate the sun's energy. Instead, Bauling uses closely packed shapes, such as inverted cones or pyramids, mounted flush on a flat plate to collect sunlight. The sun's energy is concentrated through the cones or pyramids into an insulated chamber with little energy loss. The collected heat can then be transported, via an inexpensive heat transfer medium like water or air, to areas where it is needed.

Because the device uses a flat surface to collect the sun's rays, it would need to be rotated to follow the sun's path. The relatively inexpensive new minicomputers could be programmed to rotate the device, so that it could adjust to the sun's regular fluctuations in position. In this way, a maximum amount of sunlight would enter the surface of the collector, and then be funneled via smaller openings into the insulated collecting chamber. In initial tests using cones as well as long rectangular based pyramids with a system of baffles, the device has heated the chamber to as high as 93°C (200°F) from an ambient temperature of 16°C (60°F) in one hour.

Bauling believes that solar heating devices do not need to be complex and expensive in order to be effective. His working model uses Styrofoam cups with aluminum foil funnels mounted in hardboard and one or two panes of glass as the collector, and, it is simple to construct. He displayed his models at UIUC's 1977 Engineering Open House. If his continued research leads to the development of an inexpensive, effective, and simple to build solar heater, the thrifty homeowner may someday be able to collect sunlight instead of heating bills during the cold winter months. ●

MEETING WATER ISSUES

Five Illinois communities will soon be able to understand more about their water quality, supply, and disposal problems, thanks to a one-year grant from the National Science Foundation's Science for Citizens program. The project, headed by Glenn Stout, director of UIUC's Water Resources Center, will involve meetings of community leaders and authorities who can provide information about water problems geared to each community. The first meetings will be held in the spring in three communities who experienced water shortages in last year's drought. ●

PEOPLE AND PLACES

Professor **Jon C. Liebman** has been appointed head of the Department of Civil Engineering at UIUC. Liebman succeeds Professor Chester P. Siess, department head since 1973. He has been associate head of the department since 1976, and a member of the faculty since 1972.

Professor of electrical engineering **Jose B. Cruz** is the 1978 president-elect of the Institute of Electrical and Electronics Engineers' Control Systems Society.

Department of Electrical Engineering professor **Franco P. Preparata** has been elected a fellow of the Institute of Electrical and Electronics Engineers. He was cited for his contributions to coding theory.

Civil engineering professor **Barry J. Demsey**, with **Atef Elzeftawy** of the Illinois State Geological Survey, has received the Transportation Research Board's annual K. B. Woods Award for the best paper in the area of design and construction of transportation facilities. ●

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inside outlook:

UIUC ENGINEERING DEGREES
COMPUTER SIMULATION OF THE NERVOUS SYSTEM
CERAMIC-METAL BONDING
MODELING OF THE PETROCHEMICAL INDUSTRY
DEPARTMENT HEAD DIES

UIUC PACES NATION IN ENGINEERING DEGREES

A national survey shows that last year the University of Illinois at Urbana-Champaign led the nation in engineering doctoral degrees conferred. It also showed that UIUC is the only university to rank among the top five in numbers of degrees conferred at all levels. The data from the Engineering Manpower Commission survey of 290 engineering schools indicate that UIUC awarded 6 percent of all engineering doctorates in the nation, 3 percent of all engineering master's degrees, and 2 percent of all engineering bachelor's degrees. ●

NEURONIC BEHAVIOR

What has over ten billion units, and lets us eat, drink, and be merry? The human nervous system, of course, whose over ten billion neurons interact to control a wide range of behaviors. How these neurons manage to control behavior is one of the most difficult and exciting questions in science today, because an understanding of this mysterious, complex system may someday allow treatment of serious nervous disorders, as well as a greater understanding of human behavior.

A bioengineer at the University of Illinois at Urbana-Champaign is using engineering techniques to investigate the nervous system. Dr. Michael Merickel, a visiting professor with the Bioengineering Faculty and the Department of Physiology and Biophysics, is studying the relatively simple nervous system of the snail. He has chosen a single behavior, feeding, and through a combination of sophisticated biological and engineering techniques, he is developing a new way to investigate the relationship between neuron function and behavior.

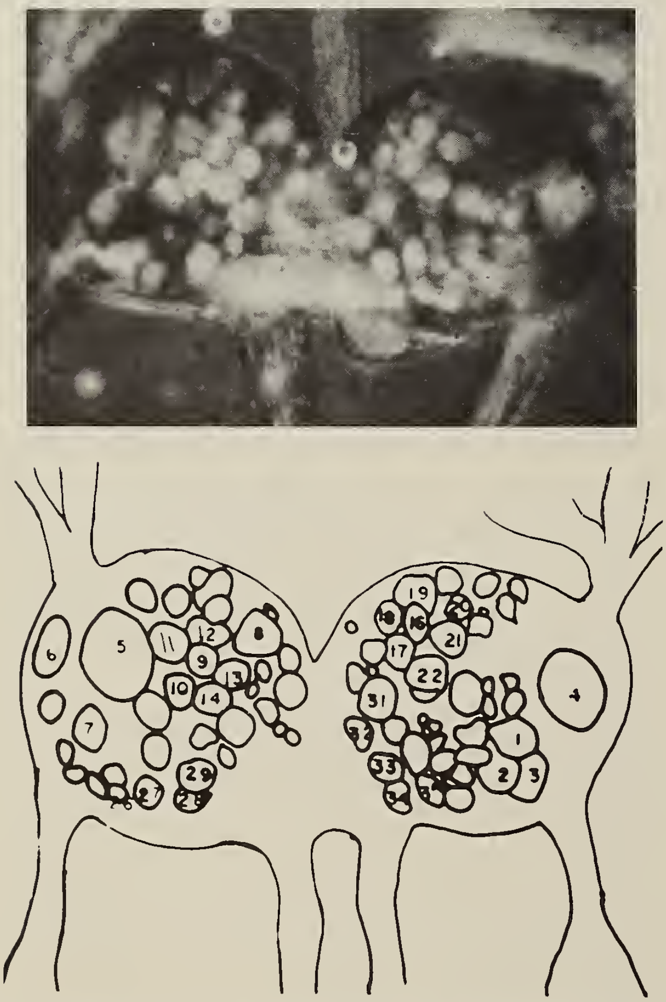
The nervous system can be seen as a complicated electrical circuit, which responds to different patterns of electrical input, and generates different patterns of electrical output. Because it is an interrelated network, an understanding of how the whole system works cannot be gained simply from understanding how a single unit, the neuron, functions. Instead, the interaction of neurons needs to be understood, and engineering techniques are proving useful in this context.

Merickel is making use of computer simulation to sort out which factors in the snail nervous system are basic to its performance. The ongoing biological system is so complicated that sorting out the relationship between factors is well nigh impossible. By devising a computer model, based on biological data, which can display similar features, it may be possible to identify just what is needed for the system to work.

Investigation begins by using stains to determine how the neurons which control feeding are connected. Then the firing patterns of these neurons are analyzed, using specialized equipment to measure the electrical properties of each cell. Merickel has developed a single-electrode voltage clamp, which, because it uses only one electrode instead of the two previously needed for cellular current analysis, can measure membrane properties in cells too small for traditional equipment.

By combining these measurements with electrical engineering theory, an equivalent electrical circuit model can be proposed that would simulate the activity of the biological system. Control or systems theory, which uses new kinds of mathematics to relate an indefinite number of input and output variables, can generate a transfer function which relates the electrical input and output found in the nervous system. This transfer function is then used to construct the computer simulation, which ideally, would display the same pattern of electrical activity as the neurons themselves.

At present, computer simulations of the snail nervous system have been able to generate a bursting pattern similar to the ones found in the system itself, but not the repetitive bursts characteristic of snail feeding, as well as a large number of other behaviors. Continued research, combining data from electrophysiological measurement with sophisticated circuit modeling, may eventually be able to elucidate which electrophysiological factors are basic and important to nervous system function. Once such knowledge is available, the understanding of human behavior and the treatment of nervous system disorders can progress at much more than a snail's pace. ●



A photomicrograph of the snail ganglion (cluster of neurons) that controls feeding shows the individual cell bodies of neurons as light spots. Many of these same cells can be found from preparation to preparation, allowing the construction of a cell map (below). UIUC bioengineering professor Michael Merickel is using sophisticated bioengineering techniques to measure the electrical properties of the cells, and to devise a computer model which simulates their function, in order to better understand the relationship between the nervous system and behavior.

BONING UP ON BONDS

"The hip bone's connected to the thigh bone . . ." goes the song, but sometimes that connection can be broken. In cases such as hip-shattering injury, a prosthesis may be implanted so that the individual can recover his ability to walk. Ideally such a prosthesis would be both strong and biocompatible, so that the bone could grow around it. Metal is used in these devices because of its durability and strength, and a polymer coating is placed on the portion near the bone to allow skeletal attachment. But the polymer coating now being used is not fully compatible with biological tissue. Ceramics, in place of the polymer, are being considered as potentially useful coatings for these devices.

Medical interest is high in ceramic material that may prove useful, and a team of UIUC engineers and biologists is testing several materials to determine how well the ceramic bonds to the metal it would coat. The ceramic-metal adherence is vital to the continued functioning of the device, because skeletal attachment depends on the metal *and* the coating remaining firmly attached to the bone. The team is studying the ceramic-metal bond in conditions resembling the body environment, hoping to understand more about the adherence needed for the device to function.

Ceramic engineering professor Sherman D. Brown, in association with J. L. Drummond, D.D.S., veterinary anatomy professor Mark R. Simon, and two graduate students, is finding that the materials do not fare well under experimental conditions. There is a change in the adherence of the ceramic to the metal, usually a lessening in the strength of the bond, and now their research is aimed at understanding the mechanisms underlying this potentially dangerous change.

Their work involves both *in vivo* (using animals) and *in vitro* (using solutions) preparations. The *in vitro* work involves small buttons of orthopedic metals sprayed with a ceramic such as aluminum oxide. An arc plasma gun, which melts the ceramic, is used to spray the material onto the roughened button; the result is mechanical locking with some chemical bonding between the metal and the ceramic. The buttons are then placed in solutions which represent various characteristics of the body environment. The results of these experiments may help to determine which physiological aspects are crucial to the performance of the ceramic-metal bond.

Not only are the investigators finding that prolonged exposure to physiological media causes reduced adherence, but also that a common sterilizing technique used on the prosthesis before surgery affects the strength of the bond. Autoclaving is used to sterilize the device by heating it to approximately 121°C (250°F), but the treatment apparently causes a dramatic drop in the strength of the bond.

There have been some puzzling findings. For example, a few specimens, without autoclaving, showed increased adherence after exposure to the physiological medium. A better understanding of the nature of the ceramic-metal bond will lead to the use in the future of materials and procedures which will maximize the strength and durability of prosthetic devices. This would mean, of course, that once implanted in hard tissue like bone, medical prostheses could be trusted to stick around. ●

THE SUPPLY IS THE LIMIT

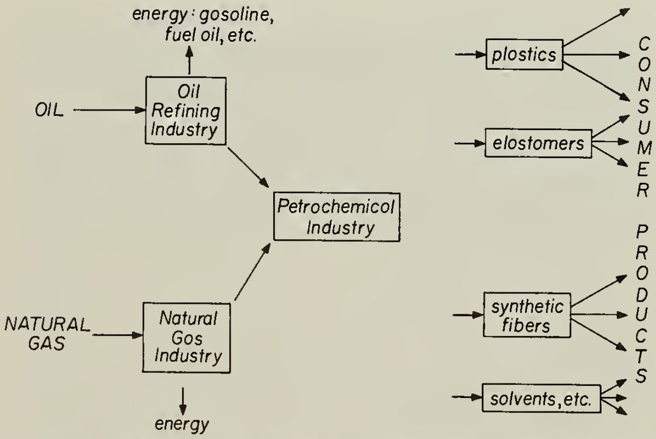
Variety may be the spice of life, but the variety of consumer products dependent on the petrochemical industry is more than just seasoning. Plastics, rubber products, synthetic fibers, solvents, etc., have become more like staples in the consumer's diet, and they all depend on the oil and natural gas the industry uses to create them. The petrochemical industry transforms the few simple molecules found in oil and natural gas into the more complex molecules used to make a variety of consumer products. But today the industry is faced with the knowledge that the supplies of these natural resources are limited.

How this limitation of resources will affect the petrochemical industry's operations requires an understanding of how the industry has functioned in the past, and how efficiently it now uses resources. Such understanding could be used to predict how future changes in technology and resource supply will affect the industry as a whole. One way of gaining this understanding is through the use of mathematical modeling.

A mathematical model of resource management in the petrochemical industry has been devised by UIUC chemical engineer Mark A. Stadtherr in association with University of Wisconsin chemical engineer Dale F. Rudd. It is a linear programming model based on the inputs and outputs of the chemical processes involved in the industry as a whole. It can be used to study long-range patterns of industrial resource management, patterns that are important in understanding how the industry can work to minimize resource consumption.

Applying the model to industrial behavior shows that in the past technological change (the switch to new and different manufacturing techniques) has led to more efficient resource use. Efficient resource use is good business practice because it tends to lower production costs, but it also means that resources are conserved. In other words, over the last several decades, the petrochemical industry has developed into a form nearly optimal with respect to resource consumption.

But the critical issue is not how the industry behaved in the past, but how it will behave in the future, in the face of limited supplies of natural resources. By projecting various scenarios in which raw materials and available processing techniques change, the model can be used to understand more about how limitations in resources may affect the functioning of the industry as a whole. This can assist the industry in defining areas of research and development, with an eye to effective future resource management. This may ensure that a variety of consumer products can remain a staple, not a hint of seasoning, in our future consumer diets. ●



UIUC chemical engineer Mark A. Stadtherr and a colleague have developed a mathematical model of resource management in the petrochemical industry which can be used to understand how the industry as a whole can operate to minimize resource consumption.

HEAD OF AGRICULTURAL ENGINEERING DIES

Professor Frank B. Lanham, head of the UIUC Department of Agricultural Engineering, died February 11. He was 64. Professor Lanham headed the department since 1955, and the atmosphere of leadership he created has been cited as a special ingredient in the success that graduates of the program have enjoyed.

Professor Lanham was active in many professional and engineering education societies. He became president of the American Society of Agricultural Engineers in 1976, and had held administrative positions in the American Society for Engineering Education, Engineers' Council for Professional Development, and the Engineers' Joint Council. He was a member of the Association for Cooperation in Engineering and of the Soil Conservation Society of America. In 1974, he was the ASAE Massey-Ferguson medalist "for the advancement of engineering knowledge and practice in agriculture."

In a tribute, his friend and colleague Benjamin A. Jones spoke of Professor Lanham's devotion to education, willingness to be a leader, zest for living, and ability to listen to the problems, concerns, and aspirations of students and staff. Professor Lanham's warmth, congeniality, and belief that empathy is the essential quality in effective administration, allowed him to enrich the lives of all who knew him. ●

PEOPLE AND PLACES

Wilbert F. Stoecker, Department of Mechanical and Industrial Engineering, has received the F. Paul Anderson Medal, the highest technical honor of the American Society of Heating, Refrigeration and Air Conditioning Engineers. He is the fourth UIUC faculty member to receive the award.

Civil engineering professor emeritus **Nathan M. Newmark** has been appointed chairman of the U.S. Geological Survey's advisory committee on earthquakes.

C. Marvin Wayman, of the Department of Metallurgy and Mining Engineering, will receive the Mathewson Gold Medal of the American Institute of Mining and Metallurgical Engineers, bestowed on the author of the paper considered to be the most notable contribution to metallurgical science during the period under review.

Electrical engineering professor **Nick Holonyak, Jr.** has been appointed to the editorial board of the *Journal of Applied Physics* and *Applied Physics Letters*. The appointment is for a three-year term. ●

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inside outlook:

CAMPUS STEAM CONSUMPTION STUDY
DIRECT CONVERSION OF HEAT TO ELECTRICITY USING FERROELECTRIC CERAMICS
AUTOMATIC SOIL CLASSIFICATION
UIUC SECOND IN RESEARCH FUNDS
FATIGUE RESISTANCE IN FLAME-CUT SURFACES

CONSERVATION BEGINS AT HOME

Universities as well as individuals are feeling the energy crunch, and as costs rise, both are trying to minimize energy consumption. About the best the individual homeowner can do is adjust the thermostat, tack up some insulation, and hope for the best. While a university has more complex problems, it also has another option; it can turn to "in-house" experts to help determine how to reduce energy use. UIUC has done just that. Mechanical engineering professor Curtis O. Pedersen, together with David N. Donahoe and David D. Metzger, is analyzing the energy consumption of the Urbana-Champaign campus. From their study, they hope to determine what future steps should be taken to reduce the energy consumption of the University as a whole.

UIUC has already made the obvious operational changes (like adjusting thermostats). But there are other energy-saving alternatives. Energy-inefficient heating/cooling systems can be modified, building structure can be changed, class schedules altered, and the public's habits can be changed to make it more energy conscious. Choosing the best combination of these alternatives requires an understanding of how each affects energy consumption.

To gain more insight into these questions, the researchers analyzed steam consumption for the campus over a three-year period. While they found that outside temperature does effect energy use, they also found that a large component of energy consumption was not affected by weather changes. By comparing weekday with weekend consumption, they also discovered that while occupancy had some effect on steam use (for air conditioning) in the summer, it had a negligible effect in winter.

Energy use varied among buildings because they differed in their structure, heating/cooling systems, and function. By identifying large energy consuming buildings and rating them, the group was able to assess the impact that individual buildings have on total campus energy use. Now they have chosen several of these "energy hogs" for detailed analysis, using a computer simulation program.

The simulation uses a program called BLAST (Building Loads Analysis and System Thermodynamics) developed by the Army Construction Engineering Research Laboratory, in association with UIUC researchers. With the BLAST program, building characteristics can be described using a special input language. This information is combined with daily weather data to simulate the energy consumption of a building over a period of time. Programs on six campus buildings are being prepared, and a comparison will be made between the actual consumption data and the results of the BLAST model study.

This comparison should yield some valuable insights. Among the many variables affecting energy use are the contributions made by the sun, the conduction through walls, and outside air temperatures. Computer simulation can quite accurately determine the effects of these variables, but it is not as accurate with other factors such as the leaking of outside air into buildings. A comparison between the results of the simulation and the actual consumption may make it possible to accurately determine the effects of these and other variables on energy use.

In this case, as in most others, there are no easy answers. But through careful analysis of the various factors contributing to energy consumption in individual buildings, an accurate understanding of what measures will be effective can be gained, and informed choices can be made about what steps the University can take in the future. By putting its own house in order, UIUC may also help other institutions in their efforts to minimize energy consumption. ●

THE POWER OF SILENCE

The sound of the American Revolution was "the shot heard 'round the world." The sound of the Industrial Revolution was the grinding of wheels and cogs, the machinery needed to harness energy for man's use. Converting heat to electricity has always been a noisy and dirty business. The hum of huge turbines and dynamos, the mechanical means of gaining electricity from coal-fired steam engines, has been a sound heard for decades. But a new and totally different means of generating electrical energy from thermal energy is being investigated at the University of Illinois at Urbana-Champaign, a means that would be clean, quiet, and revolutionary.

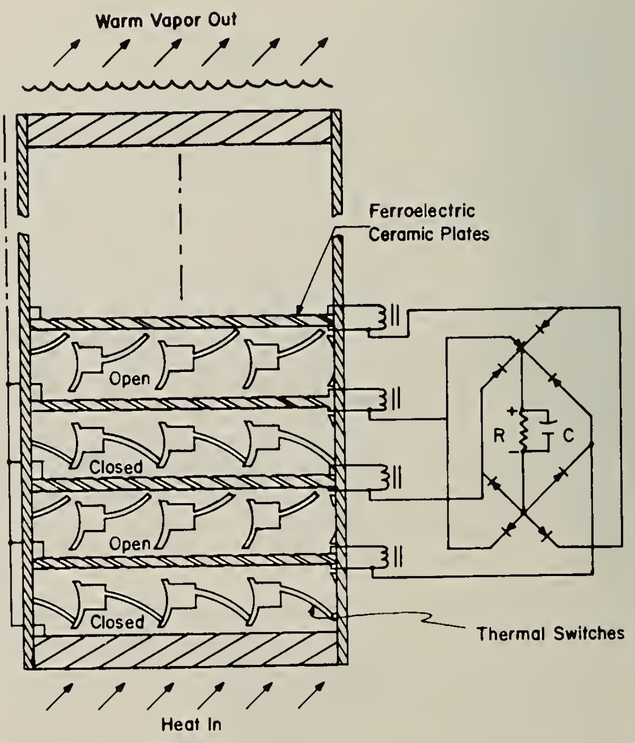
Direct conversion of heat to electricity, without intermediate mechanical steps, is the research goal. A new kind of engine has been invented that makes use of a class of ceramic materials whose properties allow electrical energy to be generated from thermal fluctuations. The device would be small, inexpensive to manufacture, and pollution free. UIUC ceramic engineering professor David A. Payne heads the research project, which is investigating the materials and design requirements for the solid-state heat engine (SHE).

This new engine uses a class of ceramic materials known as "ferroelectrics." Ferroelectric materials are spontaneously charged (polarized) crystal systems that will suddenly release their charge at a predetermined temperature. When the temperature decreases as the charge is removed (the electro-caloric effect) the material returns to its polarized state. Another increase in temperature can result in another release of electrical energy.

While this "pyroelectric effect" has been known for a long time, making practical use of it requires special design characteristics. To maintain an efficient thermal cycle, the electrical charge must be removed at the right rate relative to heat input. Also, continuous operation requires the use of a series of plates of ferroelectric materials. Each plate is designed to release electrical energy at slightly lower temperatures. This gradation of materials results in a "cascade" effect; as heat moves by a series of plates, it is transformed to electricity at ever-decreasing temperatures. If the charge is removed at the right rate, the process can be efficient and continuous, since the materials will be depolarized (releasing energy) and repolarized (containing energy) in sequential cycles.

With support from the U.S. Department of Energy, the researchers are investigating the ceramic materials needed for this dielectric power conversion. They are building test equipment and preparing new materials, seeking a practical means of growing single-crystal systems and aligning polycrystalline ceramics in a way that will allow the maximum conversion of thermal energy. The envisioned SHE would be small and suitable as local power generators in homes, on ships or planes, wherever heat is available and electricity is needed.

Heat can be generated by a number of means — most appealing are the prospects of using solar heat, or waste heat generated by other industrial processes. The device would be inexpensive to manufacture, and the estimated "energy pay-back time" of a typical engine could be a mere six days of continuous operation. And the device has the added advantage of being a pollution-free means of generating power. Obviously, this proposed solid-state heating engine, making use of the polar properties of ferroelectric ceramics to convert heat to electricity in a small, inexpensive device, has the potential to bring "power to the people" in a new and exciting way. ●



The solid-state heating device and associated electronics would directly convert thermal changes to household current. The engine makes use of the polar properties of ferroelectric ceramics, and these materials are being investigated by UIUC ceramic engineering professor David A. Payne and his colleagues.

MAPPING BY THE NUMBERS

A picture may be worth a thousand words, but it can also be worth millions of digits of valuable information, if the picture is an aerial view of a large land area, and the goal is to distinguish soil types in the region. Soil mapping, an important means of identifying soils in an area, has traditionally been done through air photo interpretation. A trained soil scientist can deduce the characteristics of soils from subtle variations in the photograph, minimizing the need for field soil sampling.

But conventional photo interpretation techniques are time-consuming, and require highly trained personnel to accurately identify soil types. University of Illinois at Urbana-Champaign civil engineering professor Kam Wu Wong, together with several departmental colleagues, is developing a soil-mapping method without these limitations.

It is a computerized technique that uses digitized terrain information extracted from aerial photographs. Their method assigns numbers to various relief and drainage parameters, and then computes the soil type from this terrain information. Research results indicate that small differences among the many similar surfacial soils found in Illinois can be detected using this approach.

While the use of digital elevation and drainage data shows promise in the automatic classification of surfacial soils, the UIUC researchers suggest that a systems approach may be most useful for soil identification. The systems approach makes use of modern remote-sensing and automatic mapping techniques to identify all the soil-forming factors (such as vegetation, ground temperature, moisture, drainage, and topography) as well as ground signatures of soils (such as land use, texture, and spectral characteristics).

A computer can then automatically correlate all of the relevant information, and identify the soils. Because accurate identification of soils is vital to the planning of engineering and agricultural developments, the ability to automatically classify soils from the sky down, means that better plans can be made from the ground up. ●

UIUC SECOND IN ENGINEERING FUNDS

According to the American Society for Engineering Education's survey of the nation's 206 engineering and technical colleges, the University of Illinois at Urbana-Champaign ranks next to the top nationally in funds for engineering and engineering-related research.

Only the Massachusetts Institute of Technology topped UIUC. In separately budgeted research, MIT led with $25,523,555, followed by UIUC with $19,886,000. In totals of engineering and engineering-related research, MIT led with $59,013,732, followed by UIUC with $25,007,000. UIUC accounted for 4.96 percent of the nation's total of $504,094,000. ●

ROUGH BUT READY STEEL

Reducing costs can often result in a reduction in quality, but an economical means of cutting large components from steel plate is proving superior to more expensive methods. The large components used to build heavy equipment can be cut from plates of steel using the heat generated by an oxygen torch. Flame cutting is a less expensive alternative to traditional machining of steel, and research at UIUC indicates that a good flame-cut surface can have superior resistance to stress.

The oxygen torch uses the steel itself as fuel, because the jet of oxygen, when applied to preheated metal, reacts with the iron in the steel and produces the heat for cutting. Unlike smooth machine cuts, the resulting cut has a rough texture, an altered chemical composition, and changed metallurgical microstructure. These characteristics may strongly influence the performance of the surfaces.

In the Department of Metallurgy and Mining Engineering, professors Carl J. Altstetter and Fred V. Lawrence, Jr., and their colleagues, have been studying the fatigue resistance (performance under repeated loads) of flame-cut surfaces. While grooves in smooth surfaces tend to promote cracks under stress, the even, slightly rough, flame-cut surface shows a surprising increased resistance to fatigue crack formation. Research is now being conducted on the effects of large gouges on the performance of these rough surfaces.

The investigators are also interested in understanding the reasons for the superior performance. Heat treatment is known to improve the mechanical properties of steel, but is it the heat itself, the surface roughness, the oxidizing effect of the flame on the iron, or some combination of these three factors that is responsible for the increased performance?

Work is being done on the effects of flame cutting of steel that has been previously heat-treated, and on cuts made with superheated gases such as nitrogen, helium, and argon. This "plasma cutting" melts the metal without oxidation, and so could be used to separate the role of heat from the role that changes in chemical composition play in increased fatigue resistance. This research, indicating that rough flame-cut surfaces show fatigue resistance superior to that of smooth machine-cut surfaces, also rewrites an old saying. With cut steel surfaces, it seems that when the going gets tough, the rough keeps going. ●

PEOPLE AND PLACES

Three UIUC faculty have been elected to the National Academy of Engineering: **Georges A. Deschamps**, professor of electrical engineering, elected for "contributions to electromagnetic scattering, microwave engineering, and laser beam propagation"; **Thurston E. Larson**, principal scientist emeritus, Illinois State Water Survey, and professor of sanitary engineering emeritus, elected for "leadership in water supply research and contributions to environmental engineering as related to water quality, criteria, and standards"; and **George W. Swenson, Jr.**, professor of electrical engineering and of astronomy, elected for "contributions to the theory and design of radio telescopes, and to radio engineering." They bring to 24 the total number of UIUC faculty members who have received the highest distinction which can be conferred on an American engineer.

Harry H. Hilton, head of the Department of Aeronautical and Astronautical Engineering, has been reappointed to the reorganized Joint-Army-Navy-NASA-Air Force Service Life Committee, which is part of JANNAF Structures and Mechanical Behavior Working Group. Its purpose is to deal with research and development work in structures and mechanical behavior of solid propellant motors, with particular emphasis on service life assessment.

College of Engineering Dean **Daniel C. Drucker** received Columbia University's 1978 Thomas Egleston Medal, the highest honor which the Alumni Association can bestow. It is presented annually to an outstanding alumnus in recognition of technical accomplishment, the furtherance of his branch of the profession, or the application of engineering principles. The award cites him as "an engineer and educator whose contributions in each area have had singular significance for our society."

J. Francis Young, Departments of Civil Engineering and Ceramic Engineering, has been elected a fellow of the American Ceramic Society. He will complete his term as chairman of the Cements Division in May 1978. ●

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COLLEGE OF ENGINEERING
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inside outlook:

EXAMINING THE INNER STRUCTURE OF LAYER CRYSTALS
PORTFOLIO THEORY APPLIED TO CONSTRUCTION
MULTIPLE-ACCESS COMMUNICATION SYSTEMS
PARTICLE DISTRIBUTION VIA AGRICULTURAL AIRCRAFT

DEALING WITH SURFACE ISSUES

If you want to know what is inside your sandwich, all you have to do is pull it apart and look between the layers. But if you want to know what is inside a layer crystal, looking at what's between won't be very informative, since the only thing between the layers is a loosely bonded Van der Waals gap. What is interesting, however, is the surface you have exposed by pulling the crystal apart, because the newly-exposed surface can yield valuable information about layer crystal properties.

Layer crystals are a class of compounds with diverse physical properties. Among the simplest of these compounds is titanium disulfide, which sandwiches a plane of titanium atoms between two planes of sulfide atoms. This sheet is weakly bonded to like sheets above and below, forming gaps which allow the layers to slide over one another, making some layer compounds good lubricants (like graphite).

Until recently, understanding of the structure of these crystals has been limited by the experimental and theoretical techniques available. But now, two experimental methods of investigation are being used at the Materials Research Laboratory at the University of Illinois at Urbana-Champaign; these techniques are proving useful in gathering information about what is going on at the inside surfaces of the crystals, and can be used to better understand the nature and potential of the compounds.

Physics professor F. C. Brown and associate C. H. Chen, with graduate students Walter Fabian and K. C. Woo, are studying the characteristics of the inner surfaces of layer crystals. By placing a crystal in ultrahigh vacuum and then pulling it apart, the sheets of atoms at a perfect surface can be exposed to experimental analysis. Analysis involves two techniques — low-energy electron diffraction (LEED) and angle-resolved photoemission spectroscopy (ARPS).

With LEED, a beam of electrons is directed onto the crystal surface, and the diffraction or interference pattern of electrons scattered back from the surface is measured. From this pattern, the atomic structure of the surface can be determined. From the intensity of individual spots created by the escaping electrons, information about subtler surface changes can be gained. The theory of these effects has been worked out by H. Hjalmarson, a graduate student with Professor J. D. Dow in the Department of Physics. The group is finding that pulling the crystal apart does not alter its atomic configuration, but it does allow the sheets of atoms to separate slightly.

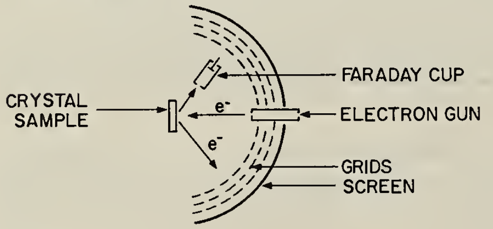
ARPS sends a stream of ultraviolet photons onto the crystal. The photons excite atoms on the surface, and electrons are emitted, which can be detected by an energy analyser. Measurement of the kinetic energy and angle of emission of the electrons can be related to momentum and energy inside the crystal, giving information about energy band structure. The experimental data from ARPS indicate remarkable agreement with theoretical band structure, although readjustments sometimes need to be made.

Layer crystals have several interesting characteristics. Titanium diselenide spontaneously locks into a new crystal structure below 200 K, forming what is known as a charge density wave or superlattice. Charge density waves form in a number of layer compounds and affect physical properties, especially conductivity. Understanding the dynamics of such phase transitions might make it possible to modify the properties of existing materials, or to create new materials with desired electrical or optical properties.

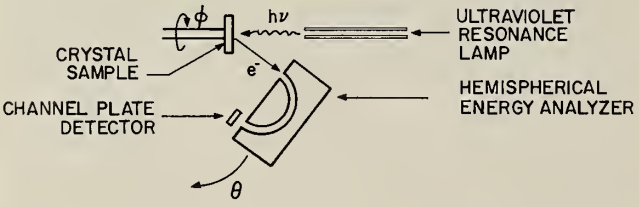
Another important property of these crystals is that the gap allows "intercalation," the placing of another element, such as lithium, between the layers, making a new intercalate compound. Recently, high-energy-density batteries have been developed which make use of this intercalation reaction for layer compounds.

The UIUC investigation of the surface characteristics of layer crystals is yielding information that may be useful in further applications. These interesting materials are complex and their full potential can probably only be realized with further understanding of their structure. So UIUC researchers will continue to study the surfaces until their structure is crystal clear. ●

LOW ENERGY ELECTRON DIFFRACTION



ANGLE-RESOLVED PHOTOEMISSION SPECTROSCOPY



The inner surfaces of layer crystals are being examined by UIUC physics professor F. C. Brown and his colleagues using two experimental techniques. Low-energy electron diffraction (LEED) measures electron diffraction patterns, while angle-resolved photoemission spectroscopy (ARPS) uses ultraviolet photons to excite electrons, which are emitted and detected by an energy analyzer. These techniques are helping to elucidate the structure of these compounds.

STRENGTH IN DIVERSITY

Unless your immediate goal is to make an omelette, putting all your eggs in one basket can be a risky business. Knowing this, investors distribute their nest eggs among a variety of investment opportunities, hoping to maximize return while minimizing risks. The theoretical concepts used to devise the most satisfactory portfolio for each investor, can also be applied to areas other than investment. University of Illinois at Urbana-Champaign civil engineering professor LeRoy T. Boyer, with Antonio J. Vergara, has taken portfolio theory into another realm, construction, and has shown how the concepts used to devise the ideal portfolio for investors can also be used by construction firms to select new projects and determine bid prices.

Portfolio theory can be applied to construction, because the collection of projects with which a construction firm is involved can be seen as a portfolio. Each project has individual risk/return characteristics, which can be mathematically analyzed to yield information about the contractor's standing on each project. These numerical values can then be combined for a view of all the projects with which the firm is involved and the correlation between existing projects can be determined.

Correlation is the crucial step, since choosing new projects which share many elements with existing projects may increase risk, but not return. But if the firm has a portfolio view of their present standing, the risk involved, and the rate at which the risk will be resolved (as projects are completed), it can seek to bid on new projects which will be advantageous to a possible new portfolio. Since the contractor is aware of the interrelationship among his firm's projects, his choice of new projects and bid prices will reflect the risk/return need of the firm as a whole.

The idea, of course, is that the whole is more than just the sum of its parts. In any investment there is risk and return, but this application of portfolio theory to construction helps reduce the risk of the bottom dropping out of a basketful of construction projects. ●

SPREADING THE SPECTRUM

The television set is a single communication device with many senders and receivers. It allocates frequency bands and time slots to allow a range of programs to be transmitted through it. The viewer can wait until the time for his show arrives, or change channels to get the show he wants. In both cases his program choices are limited by the available channels and the hours of the day.

Much the same limitations apply to more elaborate communications systems, such as satellite communication. In the past, time-division (the hour of the day) and frequency-division (the channel) were both used to allow different senders and receivers to communicate via satellite. But in today's world of increased information flow, new and more sophisticated techniques for multiple-user communication are required to handle the increased demand for access.

At UIUC's Coordinated Science Laboratory, electrical engineering professor M. B. Pursley and his colleagues are engaged in research on alternatives to time-division or frequency-division multiple-access communication. They are interested in how signals can be effectively sent in the same frequency band at the same time, and they are studying this issue for a specific class of systems called spread-spectrum multiple-access communications systems (MACS).

While there is always some residual interference in any practical spread-spectrum multiple-access system, the signals can be designed so that the interference is reduced to a tolerable level. For instance, each signal can be encoded differently so that only the message intended for a given receiver would be picked up among all the messages being sent in the same frequency band at the same time. This encoding process increases the signal bandwidth (hence the name spread-spectrum) but provides many desirable features, including multiple-access capability, multipath distortion reduction, and interference rejection for unwanted signals.

An important aspect of spread-spectrum communication theory is the problem of selecting codes which will provide multiple-access capability for a large number of transmitted signals. This problem is the subject of a joint project at CSL involving Pursley, electrical engineering professor D. V. Sarwate, and mathematics professor R. J. McElicee. Another topic being pursued by Pursley, with research assistants D. E. Barth and F. D. Garber, is the analysis of spread-spectrum systems for various alternative combinations of signal designs, modulation schemes, channel models, and receiver structures. The goal of this research is to obtain tools to aid the communication engineer in the design and implementation of the most efficient spread-spectrum communication system for a given application.

Beyond the question of designing and implementing specific multiple-access schemes lies the broader conceptual problem of determining the fundamental limits on the rates of information transmission in a multiple-terminal communication system. For a given system, what rates are achievable? In other words, at what information rates, no matter what the mode of transmission or the coding technique employed, can multiple data signals be reliably transmitted to different receivers via a specific multiple-terminal communication channel? Various mathematical descriptions for sets of achievable rates have been established in the past, but for many of these rate regions, a computable characterization has not been found. Pursley and former research assistant B. E. Hajek recently obtained a computable information-theoretic description of a certain achievable rate region for a specific class of channels called binary-input broadcast channels. This description models systems where a single transmitter broadcasts different information to multiple receivers.

An example of this type of channel would be a television set which allows all viewers to see the same picture but lets them choose which language they want to listen to. The transmitted signal consists of a common video signal of interest to all receivers, and a separate audio signal which is of interest to only a portion of the receivers. "Stay tuned, same time, same station" used to mean watching the same program, but this research might let a lot of different people tune in to the show of their choice. ●

The nozzle under this model of an airplane wing ejects tiny styrofoam pellets as the wing is towed, to simulate distribution of materials during flight. It is part of a UIUC research project investigating the trajectory of particles ejected from agricultural aircraft.

THE AIM OF PLANES: FALL ONLY ON THE GRAINS

The rain may well fall on the just and the unjust, but modern agricultural practice demands that materials other than water fall exactly where they are needed most. Fertilizers, pesticides, fungicides, and seeds can all be spread from agricultural aircraft, which can be a more economical method than surface-based systems. It also has the advantage of being able to quickly spread materials, such as pesticides, over a large area, an important consideration when insect infestation threatens. But it is not as simple as hopping into a plane and puffing out particles over the fields. The materials need to be accurately distributed from the aircraft, to avoid damage to other crops and unwanted effects on other nearby farming operations.

Accurate distribution requires knowledge of how particles travel when ejected from the plane, and three University of Illinois at Urbana-Champaign researchers are working to establish methods of predicting the path of materials ejected from agricultural aircraft. Allen I. Ormsbee, Department of Aeronautical and Astronautical Engineering, B. J. Butler, Department of Agricultural Engineering, and Barry J. Jacobsen, Department of Plant Pathology, are involved in the project, in collaboration with the National Aeronautics and Space Administration.

They have constructed a mathematical model of particle behavior under flight conditions, and devised a computer program describing the trajectories of the particles. The aircraft itself affects the paths the ejected materials will take, and now research is centered on experimental testing of the effects of the wing-generated disturbance on the particle trajectory.

This information about the trajectory of particles ejected from agricultural aircraft can be used to alter the design of planes now in use, and in the design of new planes, to allow more accurate distribution. Success in developing more accurate techniques for the aerial application of agricultural materials may just elevate farming to a new plane. ●

PEOPLE AND PLACES

Professor **Martha E. Williams** of the Coordinated Science Laboratory has been elected vice president of *Engineering Index*. She has served on the board of directors for the past two years, and has been a trustee of the corporation since 1974.

Professors **George H. Miley** and **John J. Dorning, Jr.**, are among 21 persons named fellows of the American Nuclear Society. They were selected for outstanding research, technical leadership, and teaching in the nuclear field.

The American Society of Agricultural Engineers has awarded professor emeritus **Ralph C. Hay** its first annual Kishida International Award. The award recognizes "outstanding contributions to engineering, education, research, or other programs that have improved food production, living conditions, and/or education for people living outside the United States."

Mechanical engineering professor **John C. Chato** will receive the 1978 Charles Russ Richards Memorial Award, a joint award of Pi Tau Sigma and the American Society of Mechanical Engineers, which recognizes outstanding achievement in mechanical engineering.

Physics professor **Peter Flynn** is the new director of the Materials Research Laboratory at UIUC. He succeeds Robert J. Maurer, who headed the laboratory for 15 years.

The **University of Illinois student branch of the American Society of Agricultural Engineers** has been named the 1978 runner-up in the annual Farm and Industrial Equipment Institute trophies competition. The awards are presented to student branches with outstanding records of activities and achievements for the year.

Civil engineering professor **Richard S. Engelbrecht** was named an honorary member of the Abwassertechnische Vereinigung, the West German member organization of the Water Pollution Control Federation, of which Engelbrecht is president. ●

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COLLEGE OF ENGINEERING
VOL. 20, NO. 2, SEPTEMBER 1978

inside outlook:

NEWLY DISCOVERED SEMICONDUCTOR PHASE
RESEARCH ON DETERMINING BONE HEALING
PREDICTING MATERIAL FRACTURES
DECOMPOSITION IN HIERARCHICAL ORGANIZATIONS

A NEW PHASE OF SOLID-STATE RESEARCH

Phonon winds creating anisotropic clouds? No, it's not the weekend weather report, but the result of basic research in solid-state physics at the UIUC Materials Research Laboratory and the Department of Physics. Experimental investigation of the elemental semiconductor germanium has generated pictures of a newly discovered semiconductor phase, pictures that give unexpected and valuable information about the characteristics of these important materials.

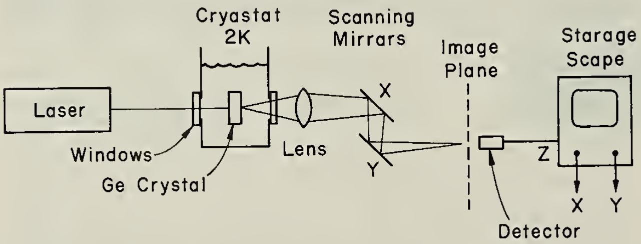
Transistors are made from semiconductor materials, and transistors are at the heart of all kinds of technological innovations, from digital watches to the largest computers. These materials, which act as insulators at low temperatures, conduct electricity when optically or thermally excited: when light or heat strikes the crystal, it promotes electrons to a higher energy state, leaving "holes" where the electrons were. Both the excited electrons and the holes are mobile charge carriers that can produce an electric current.

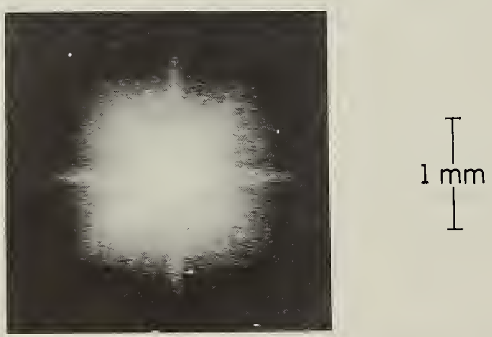
The electrons (negative carriers) and holes (positive carriers) are attracted to each other, and at low temperatures they form bound electron-hole pairs, called excitons. With increasing light, the density of the excitons increases, and recently it was postulated that this exciton gas could condense, forming a "metallic-liquid" phase inside the solid crystal. Subsequent work determined that this newly discovered phase takes the form of many small droplets, about 5 μm in size, each containing about 100 billion carriers. These individual droplets are surprisingly good electrical conductors, like copper, even though the density of the mobile charge carriers is one million times smaller. The electron-hole droplets have a lifetime of only 40 microseconds, due to the recombination of electrons and holes, so a continuous light source is needed to support their population. If the light is removed, the droplets disappear, and the crystal again becomes insulating.

Further experiments determined some properties of the cloud of electron-hole droplets, though no one had ever actually seen it. James Wolfe, assistant professor of physics, with graduate students Michael Greenstein and Paul Gourley, obtained the first photographs of the cloud of droplets using a combination of optical and low-temperature techniques. They cooled a single crystal of ultrapure germanium to 2 K (−271°C or −455°F) and then optically excited the crystal with a laser beam. This produced within the crystal a cloud of electron-hole droplets, which generated infrared light as the photo-excited elecrtons continuously recombined with the holes. By devising a special imaging system, using scanning mirrors and an infrared-sensitive photodetector, this infrared luminescence coming from the crystal produced an image of the droplet distribution within the crystal itself.

The resulting picture was striking. Instead of the expected hemispherical cloud, centered on the laser excitation point, the researchers found a cloud with lobes and flares, having the symmetry of the cubic crystal. They believe that this unique shape is caused by vibrations that are set up in the crystal lattice when the excited electrons fall back into their lower energy state. Lattice vibrations are called phonons, and thus a phonon "wind" seems to be pushing the droplets into the crystal from the surface, where they are created. The phonon push is stronger along certain axes, producing an anisotropic (nonuniform) cloud.

This work has stimulated interest in the interaction of carriers and phonons in semiconductors, and shows that there are still basic properties to discover in these important materials. On the practical side, a knowledge of the photo-electric properties of semiconductors at low temperatures may be valuable in the development of proposed low-temperature devices. Such applications may depend on this kind of basic research, where Wolfe and his colleagues found the answer to a cloudy question "blowin' in the wind." ●





The first photograph of a cloud of electron-hole droplets in germanium was obtained by UIUC researcher J. P. Wolfe and his colleagues by infrared imaging. A single crystal (8x8x3 mm) was cooled in a bath of liquid helium and optically excited with a 1-watt argon-ion laser. An oscilloscope photograph shows the anisotropic feature of the cloud inside the crystal.

THE TELL TALE TAP

While time may indeed heal all wounds, how much of it is needed for complete healing may often be the important issue. In the case of broken bones, information about the rate of repair is needed to estimate accurately how long a cast must be worn, and often this information is not available from x rays or a patient's description of discomfort. Recently, an experimental technique has been developed to determine the strength of the healing bone. Physicians can lightly tap one end of the bone while measuring (with an accelerometer) the motion of the other end. As the bone heals, the response to the tapping changes dramatically. This response change could be useful in determining the rate at which the bone is healing.

At the University of Illinois at Urbana-Champaign, Professor James W. Phillips, of the Department of Theoretical and Applied Mechanics, and two colleagues, were interested in determining why this technique works. In order to explain the clinically observed results they constructed a mechanical model, using an aluminum "bone" with a simulated partial fracture. By mounting electrical resistance strain gages, which measure the amount of stretching at a given point, on either side of the fracture, they could monitor the response of the "bone" to a stress wave produced by tapping one end. The researchers found that the experimental results closely matched those predicted by stress-wave theory, indicating that the general method should be useful in clinical diagnosis of the rate at which a fractured bone is healing.

The procedure may also be useful in detecting serious flaws in structures similar to bone. Since cracks in rods and beams would also show this characteristic response to the procedure, the technique has potential as a nondestructive way to test the strength of these products. By boning up on clinical research, it appears that Phillips and his coworkers may have also tapped into a useful technique for quality-control testing. ●

CRACK TRACKING

Breakfast cereals aside, it's not a snap to predict when a crack will cause a component to pop. In fact, a number of investigators are applying a variety of research methods to understand crack initiation and propagation under the auspices of UIUC's Fracture Control Program. The program uses the University's research facilities to determine when and how fractures will occur in various materials, with the goal of predicting and controlling fractures in the outside world.

The stresses and strains that materials are subjected to can be simulated, using a computer-controlled servohydraulic test system, and measurements taken of the time it takes for a crack to appear and the material to fracture. But this process, because it simulates real world events, can take an extremely long time. Is there an accurate but faster way to predict crack initiation and propagation, avoiding the time-consuming process of direct simulation?

There is, and mechanical engineering professor Darrell F. Socie is involved in implementing it. Small cylindrical samples of a material are first tested under repeated loads. Then, the stress and strain limits determined from these tests are extended to notched plates (comparable to real world components), and used to devise a computer model of the formed material. This model can then be used to determine which factors are crucial to the initiation and propagation of cracks in a specific component.

The manufacture of materials always involves the generation of tiny irregularities, and cracks begin where there is a defect in the microstructure of the material. Under repeated loads, dislocations in the material's inner structure will collect around this defect. As the dislocations move together, a crack forms. The crack propagates (because it concentrates stress) and eventually, the material fractures.

Time-consuming direct simulation of these conditions applies many varying loads over time, not all of which lead to crack formation and fracture. By using the computer model, in a process called "spectrum editing," the loads that are essential for the appearance of a fracture can be designated. Once these essential crack-inducing events have been determined, they alone can be used to test the fatigue life of a material in the laboratory, which dramatically lessens the time required to test the component. With this kind of research on crack initiation and propagation, the fatigue life of various materials and geometries can be quickly and accurately determined, which is just the kind of break that equipment manufacturers need. ●

GREY FLANNEL RESEARCH

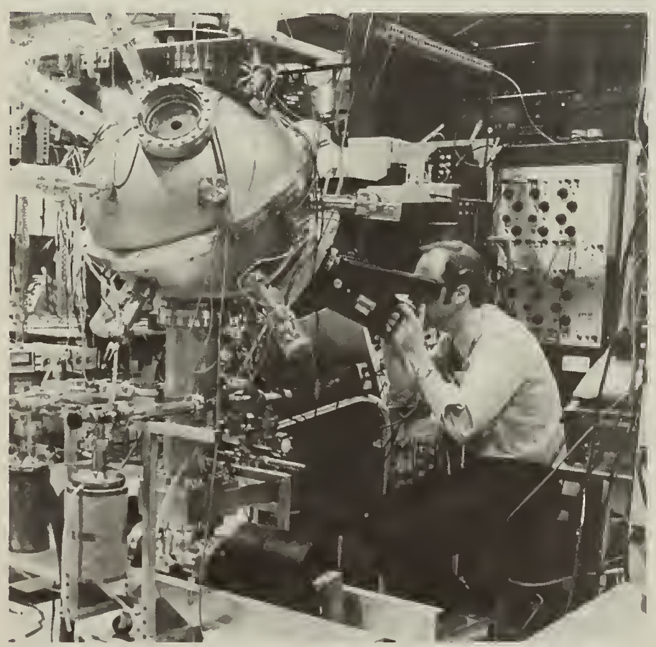
Charles Dickens poignantly described the condition of the corporate man as "skewered through and through with office pens, and bound hand and foot with red tape." Obviously, were his description completely accurate, no organization could function, but most people would agree that there are times when they feel much the same, when trying to act within a complex institution. The structure and function of organizations is necessarily complex, and efficiency can seem well nigh impossible in the maze of conflicting levels and goals.

But there may be hope. UIUC general engineering professor Wayne Davis is examining hierarchical organizations, and he has developed a mathematical model that can be used to increase the efficiency of decision-making within these complex systems. Davis uses a technique called "decomposition" which mathematically separates organizational procedures into a series of subproblems. Then, by solving each subproblem, an understanding of the overall problem of the organization can be gained.

All hierarchical organizations involve allocation of resources, sharing of information, assignment of decision-making tasks, and the coordination of operations across levels. A single organization may have conflicting goals at different levels, and so it has to make tradeoffs based on many criteria. In order to suggest efficient strategies of operation for the overall organization, the goal of each level must be determined as well as how information about these goals moves from one level to another. The model has been designed to demonstrate the role that decisions play in the resolution of various organizational conflicts and in the solution of its overall problem.

Once the model has been constructed, different decision strategies can be tested within it, to see how efficiently they function. This experimental work can then be tested against a specific class of real-world examples, to further refine the model, and to offer suggestions for improved organizational performance.

The decomposition procedure can be applied to many situations where separate units must be integrated into a whole. For example, the design and manufacture of a complex machine, such as a car, requires the integration of separately engineered parts. A university must integrate the variety of interdependent goals generated by departments, faculty, students, budget requirements, and achievement criteria. In these cases, and others like them, decision-making strategies about the allocation of resources are crucial to the efficiency of the organization. With mathematical modeling of hierarchical organizations, using decomposition theory, Davis can use the sum (and interaction) of the parts in order to understand and improve the whole. ●



Equipment used in advanced engineering research at UIUC often has a Buck Rogers quality about it. Electrical engineering professor B. E. Cherrington is studying the plasma confined on the interior of a very futuristic looking spherical diode. The diode can be used for plasma confinement studies or for the irradiation of pellets by ions accelerated by the electronic space charge fields. Research of this type plays a significant role in the development of fusion power generation.

PEOPLE AND PLACES

The National Institutes of Health have awarded a Fogarty Senior International Fellowship to **John C. Chato**, professor of mechanical engineering and bioengineering. It is the first time that a fellowship has been given to an engineer. Professor Chato will go to Zurich, Switzerland, to work at the Institute for Biomedical Technique.

Professor and Mrs. James W. Bayne have been appointed to the Danforth Associates Program. He is the associate head of the Department of Mechanical and Industrial Engineering. The program includes faculty spouses as full participants, recognizing their roles as contributing members of the college and the broader community. The program recognizes and encourages effective teaching, and offers opportunities for interdisciplinary and inter-institutional activity. Associates are appointed for a six-year term.

Mac E. VanValkenburg, professor of electrical engineering, has received the American Society for Engineering Education's highest honor, the Lamme Award. He was selected for "exceptionally outstanding textbooks on circuits and systems, for innovations in undergraduate teaching and inspired guidance of graduate students, for outstanding administration of university and professional societies, and for distinguished leadership in educational and government institutions, and research administration."

Electrical engineering professor **Raj Mittra** received the Best Paper Award of the Antennas and Propagation Society of the Institute of Electrical and Electronics Engineers.

The University of Waterloo, Canada, has conferred the degree of Doctor of Engineering *honoris causa* on civil engineering professor **Ven Te Chow** for his outstanding contribution to water resources engineering education and practice.

Richard S. Engelbrecht, Department of Civil Engineering, has been selected to deliver the Ernest Victor Balsom Commemoration Lecture at University College in London. He is the second American ever selected for this honor. ●

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COLLEGE OF ENGINEERING
VOL. 20, NO. 3, OCTOBER 1978

inside outlook:

MODELING THE MUSCULO-SKELETAL SYSTEM
STUDENTS DESIGN MACHINE TO EXPLORE MARS
CONVERSION OF ANIMAL WASTE TO LIVESTOCK FEED
LIDAR SYSTEM PROFILES SODIUM LAYER IN ATMOSPHERE
THE SUMMARY OF ENGINEERING RESEARCH 1978 AVAILABLE

ORTHOPEDIC RESEARCH WITH A TWIST

Creating a bionic man or woman is not only science fiction, it's probably more far-fetched than most TV viewers suspect. The fact is that quantitative medical knowledge about the extremely complicated human system of tendons, ligaments, and bone joints is very limited.

UIUC engineers are by no means trying to create the fictional bionic replacement parts or anything remotely related to that notion made popular by television. But they are taking the first step that leads in that direction by attempting to make the first complete mathematical model of the human musculo-skeletal system.

The analytical model being built at UIUC by professor Norman R. Miller, Department of Mechanical and Industrial Engineering, and professor Jahangir C. Rastegar, Department of General Engineering, is being designed to enable scientists to predict the level of force that will cause injury to the passive and muscular structures of the human musculo-skeletal system.

In scientific terminology, the complex system of joints, ligaments, and tendons is known as the passive structure because it doesn't exert force. The muscular system is the active structure.

The extreme complexity of the passive structure has made previous attempts unsuccessful in portraying what action takes place when a joint is moved. In fact, modern medicine does not even know exactly what gets injured when you twist your ankle, so the treatment for that injury consists mostly of guesses.

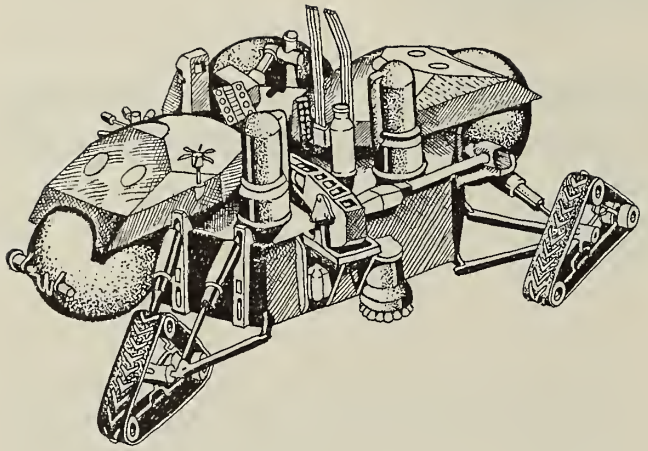
The UIUC engineers hope their precise measurements and detailed mathematical modeling will permit the analysis of the geometric surfaces of joints sliding on each other while the elastic constraints of the ligaments restrain them. This will help solve the ankle's mystery and provide better understanding of the entire passive structure.

Experiments at present are focusing on the lower leg and dealing with the ankle in particular. Working with human leg specimens from amputees, the experiments are being conducted with an apparatus that simulates the weight of a complete human body on the ankle. Then, as the ankle is twisted, measurements are made to determine the amount of force needed to cause injury and what exactly is being injured.

By correlating the injury-level force to the analytical data from the musculo-skeletal model, the researchers hope to be able, by induction, to apply their data to all people in general. Science will then have biomechanical data describing the intricacies that take place during human motion.

Data to be used in calculating the forces on individual ligaments and stresses on bones are already accumulating. Completed information about the ankle may be ready by spring. As the research continues further, even more mysteries could be solved, including the puzzling question of the exact function of the fibula, one of the small bones in the lower leg that has always perplexed investigators.

Although the mathematical model of the human musculo-skeletal system could take years to complete, the information being searched for would be a wealth of medical knowledge. The biomechanical data would be extremely valuable to orthopedic surgeons and would provide necessary information for the design of artificial joints and limbs. The research information may even explain why people get tennis elbow and lend credibility to television programs about bionics. ●



A team of six UIUC undergraduates won first place in the 1978 AIAA/ Bendix Design Competition with this design for a vehicle to explore the surface of Mars. The design was developed as a part of their course work in the Department of Aeronautical and Astronautical Engineering.

ROVER IS A MARTIAN'S BEST FRIEND

An undergraduate team from the UIUC Department of Aeronautical and Astronautical Engineering has won the $1,000 first prize in the 1978 American Institute of Aeronautics and Astronautics/Bendix Design Competition with their design of a Martian Rover. Stephan Hoffman, project leader, Brad Ashmore, Eric Barnes, Stephan Haffner, Richard Horn, and Gary Longtin designed the Rover last spring as a project for a flight vehicle synthesis class taught by professor Kenneth R. Sivier.

The problem was to design a vehicle to provide travel over varied surfaces to gather scientific data on soil chemistry, climatology, and the possible existence of life on Mars during a two-year mission to the planet beginning in 1984.

The winning design features a unique mobility system of an elastic loop on a triangular carriage dubbed the "walking triangle." Three of these "walking triangles" will propel the Rover over obstacles up to 0.5 m (19.7 in.) in height. In addition to the basic design, the team provided a complete testing and management program and a detailed cost analysis. Construction and testing of two of the Rovers would cost $445 million.

It is clear from their award that these students are going far in their selected field. Their successful design may go even farther. ●

WHAT TO DO WHEN YOU'RE OUT OF HAY

A new method of recycling animal waste into a protein-rich feed supplement for livestock is in progress at UIUC. Professor Donald L. Day of the Department of Agricultural Engineering and professor Marvin P. Steinberg of the Department of Food Science hope to apply the principles of the electrolytic cell to the production of single-cell protein from mixed liquor.

Mixed liquor results from animal manure that seeps through slots in a special barn floor and mixes with water in a storage tank below. Through a metabolic process, bacteria convert the waste into a highly nutritious meal-supplement for livestock. The liquid is then pumped into the animals' water troughs where it is consumed as their only water source.

There are several methods of converting livestock waste into high-protein feed. Each system recycles the manure for refeeding through a process that stops the odor, kills diseases, and makes the sludge palatable.

One method uses an oxidation ditch to treat manure that collects beneath a slotted barn floor. Electric motors pump oxygen into the liquid manure, allowing bacteria to use the manure as their food and simultaneously upgrade the manure from nonprotein nitrogen into protein quality nitrogen that is especially suited for nonruminant animals. The process results in a continuous flow of manure coming in and sludge going out in the form of high-quality feed that is fed back to the animals as a supplement just as rich in protein as soybean meal.

The problem with the oxidation ditch process is the high cost of electricity that is needed by the motors to continually force air into the mixture of water and waste material. The method being developed through the UIUC research project seeks to lower the cost of recycling animal waste, and maybe even make the entire process self-sufficient.

Current laboratory experiments are directed toward the possibility of using electrolysis for converting the manure into protein quality nitrogen. Based on the electrolytic cell, the new process would change the storage tank into an electrolysis conversion unit. A small DC current would be applied to the water, which would chemically break down the water into hydrogen and oxygen gas. The oxygen would be used by the bacteria to synthesize the manure into protein quality nitrogen, and the hydrogen gas would be collected for use in generating electricity.

Along with other needed refinements, the eventual success or failure of the project hinges on the hydrogen gas that is released as a by-product during the production of oxygen. Since the amount of electricity needed to chemically produce oxygen is even more than the amount needed to power the electric motors now used to pump air into the oxidation ditch, a means has to be found to utilize the free hydrogen as an energy source for generating electricity. If this can be done, electrochemical conversion of animal waste into protein would become economically attractive, especially in areas without enough available land for producing the crops that are now used for livestock feed supplements. ●

TAKE ME TO YOUR LIDAR

Imagine a dark, foggy night in central Illinois with a lonesome building off in the distance. Suddenly a shot of bright yellow-orange light stabs out from the building's roof and illuminates the clouds as it disappears into the night sky. Pulses of light continue to shoot into the night sky for more than 10 minutes. It's a scene right out of Star Wars.

The dramatic impact is even more startling when you discover that the incident is for real and is actually a frequent sight at UIUC, where the only sodium lidar system in North America dazzles the dark sky with its powerful laser. The sodium lidar system is a Department of Electrical Engineering research project being conducted by professors Chalmers Sechrist and C. S. Gardner and their graduate students. With support from the National Science Foundation and NASA, the project is designed to measure the atmospheric sodium layer which is located between 80 and 90 km (50 and 56 mi.) above the earth's surface.

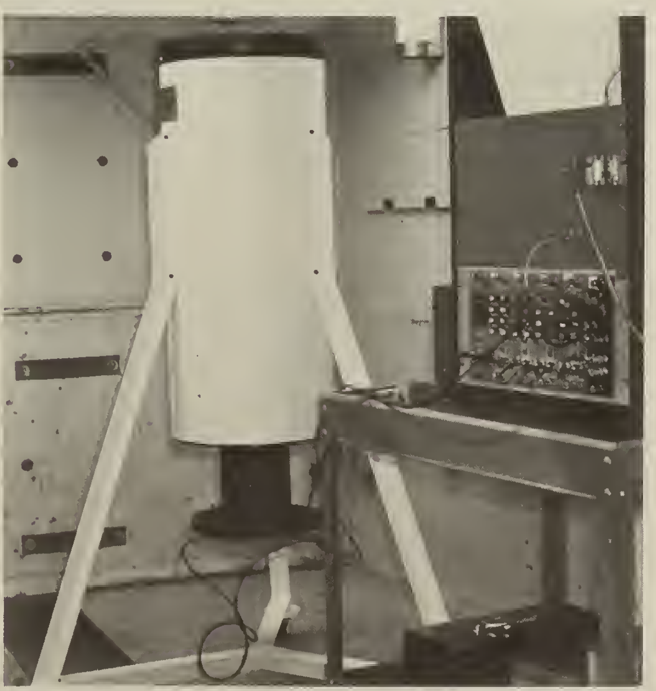
The lidar system, an acronym for light radar, combines light from lasers and a telescopic detection system to observe the earth's sodium layer. The system operates much like a radar system, but uses visible light instead of radio waves. The high-powered laser can be tuned to a frequency of the optical spectrum that corresponds to specific gases. To measure sodium, the laser is tuned to a resonance line of the sodium atom at a point very near the yellow-orange portion of the visible spectrum.

During the experiment, the laser fires very short pulses of optical energy vertically into the sky. Traveling at the speed of light, two seconds apart, these pulses of light energy travel through the atmosphere until they hit the sodium layer centered at an altitude of about 90 km. There the laser light is absorbed by the sodium atoms and reradiated back to earth.

Meanwhile, back on the rural countryside near Urbana-Champaign, a van is parked with a large telescope searching the night sky. This telescope can be moved from one location to another to receive the back-scattered light from the sodium layer. The receiving telescope system transmits the information to a photon counter that is, in turn, hooked up to a microcomputer. Later, a large computer analyzes the amount of light reradiated back to earth and calculates a profile of the sodium layer that depicts the sodium concentration and shape of the layer at the particular moment the laser was projecting light beams into the atmosphere. The only other way the sodium concentration could be obtained is through the very expensive means of sending a rocket into the atmosphere. The lidar system is quicker, less costly, and much more convenient.

Of all the gases in the earth's upper atmosphere, the lidar system is tuned to reradiate back only from sodium atoms, at the present time. The sodium layer has been chosen for study due to its suspected ability to act as a tracer of upper atmosphere motions. That is, by following the distinct layer of sodium, the movement of the upper atmosphere can hopefully be determined. It is thought that the sodium layer's movement can help in the understanding of the sun's effects on the upper atmosphere. Study of the sodium layer may help to clarify one of the links in the chain of physical mechanisms which connect the sun's electrical activity to weather systems and climate.

The long-term study will have to accumulate data for some time before any clear assumptions can be made, but already it shows that lasers can count sodium atoms 90 km away, better than you can count on the weather forecast. ●



Located in a mobile unit near the UIUC campus, this telescope system is used to gather fluorescent light from sodium atoms that have been excited by a high power laser beam. The telescope system is equipped with a photomultiplier and photon-counting equipment, which is partially visible to the right of the telescope. The photon counters are connected to a computer system which calculates a profile of the sodium layer from the measured photon counts.

. . . AND IN SUMMARY

The Summary of Engineering Research 1978 describes the research program of the College of Engineering during calendar year 1977. It provides the details of a $19.8 million program which involved 400 faculty and professional staff and 1560 graduate students working on more than 600 projects. The report covers the research activities of 13 academic engineering units, two major interdisciplinary laboratories, and two college-wide multidisciplinary programs.

In addition to abstracts of each research project, the *Summary* includes publications of the faculty, theses, and awards and honors of the faculty.

Copies of the 272-page *Summary* are available at no charge from the Engineering Publications Office, 112 Engineering Hall, UIUC, Urbana, Illinois 61801. ●

PEOPLE AND PLACES

The recipient of the first Halliburton Education Leadership Award is professor **Wilbert F. Stoecker** of the UIUC Department of Mechanical and Industrial Engineering. The $1,000 award was established by the Halliburton Education Foundation, Inc., to recognize a UIUC engineering faculty member who has demonstrated leadership in engineering education.

The American Society of Agricultural Engineers has presented Educational Aids Blue Ribbon awards to two members of the UIUC Department of Agricultural Engineering. The awards were presented to professors **Roland Espenschied** and **A. J. Muehling** in recognition of outstanding efforts and achievements in the development of noteworthy educational aids.

Professors **C. E. Goering** and **Paul N. Walker** of the UIUC Department of Agricultural Engineering have received recognition from the American Society of Agricultural Engineers for published scientific papers each authored that were chosen as honorable mention winners in the ASAE Paper Awards competition.

Professor **V. T. Chow** of the UIUC Department of Civil Engineering will be named an honorary member of the Mexican Hydraulics Association when he delivers a lecture at the group's Fifth National Congress.

The American Nuclear Society's first Student Award for Fusion Science and Engineering was presented to **Lee M. Hively**, a graduate student in nuclear engineering at UIUC. The $200 award recognizes achievement by a student and emphasizes the importance of student involvement to the future success of fusion energy. ●

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inside outlook:

IMPROVING TERTIARY OIL RECOVERY

DATA BASE DIRECTORY
OF TRANSNATIONAL CORPORATIONS COMPILED

REFUELING NUCLEAR FUSION REACTORS

A FIVE-YEAR STUDY OF ST. LOUIS WEATHER

OIL'S WELL THAT ENDS WELL

You can't get blood from a turnip, but a UIUC study may make it possible to get oil from rock — for the third time.

One of the on-going oil production efforts to reduce this country's dependency on foreign oil supplies is to develop better methods for recovering oil from existing wells that can no longer be pumped with current methods. Research has already extended the life cycle of an oil well to three stages. But the tertiary cycle is still too costly to use in most cases.

Primary oil recovery lasts until the gaseous underground pressure diminishes and the natural flow of oil ceases. Then a secondary recovery method becomes necessary and is accomplished by pumping water into the oil well to force the petroleum to the surface.

Tertiary recovery is used when water alone fails to bring up what still amounts to 70 percent of the oil reserves left in the underground well. One of these expensive tertiary methods mixes detergent-like chemicals with the water to mobilize the oil and separate it from the porous rocks that trap it.

Called surfactant flooding, this process is not economically feasible at present, partly because large quantities of these chemicals are lost in the oil reservoir. What surfactant is recovered along with the oil can be separated from the crude oil and used again for tertiary recovery.

It is believed that about half of the chemicals used in this enhanced oil-recovery process are adsorbed at the water-rock interface where oil is trapped. The loss of expensive surfactants to the oil reservoir can make this tertiary recovered oil about twice as costly as oil recovered by primary methods.

Professor J. A. Shaeiwitz of the UIUC Department of Chemical Engineering is working on a research project that he hopes will lead to the understanding of why surfactants are trapped in reservoirs so that the cost of surfactant flooding can be lowered to a feasible range. Shaeiwitz hopes to determine why surfactants are lost before the recovery process. Both fundamental and applied laboratory research are planned to increase understanding of surfactant adsorption.

First, the adsorption of surfactant solution in a packed bed of glass spheres will be measured. These results will be compared to experiments measuring the adsorption of surfactants in a bed packed with minerals found in a typical oil well.

This is a new approach to solving surfactant loss problems because the phenomena of dynamic adsorption of surfactants has not yet been studied. Previous studies were done under equilibrium conditions. Shaeiwitz feels that the dynamic properties are more important in the oil-recovery process. He proposes that the solution and solids will not necessarily be in equilibrium during reservoir flooding. This theory changes the surfactant loss problem to one of dynamics instead of equilibrium.

Though still in the development stage, the UIUC study could be a major breakthrough in petroleum research if the theory proves to be correct. This new knowledge could be applied to the development of a surfactant chemical that could be recovered and used again to lower the cost of chemical flooding. Not only would it make tertiary oil recovery feasible, but it would prove that America's oil wells are good to the last drop. ●

WHO OWNS WHOM

In an age in which the annual sales of some multinational corporations may approach the gross national product of a small independent nation, there is more than casual interest in transnational corporations. Thanks to research at the University of Illinois at Urbana-Champaign, there will soon be an authoritative, easily accessible reference source to help keep abreast of the activities of these corporations.

The *International Directory of Data Bases on Transnational Corporations* was compiled for the United Nations by the Information Retrieval Research Laboratory of the UIUC Coordinated Science Laboratory, under the direction of professor Martha E. Williams, with editorial assistance from information scientists Laurence W. Lannom and Rosemary O'Donnell.

The directory is the most comprehensive listing to date of organizations that provide data about international corporations. It is designed to lessen research time and effort by listing as many machine-readable sources as are available. The easy-to-use book contains listings of 138 organizations world-wide that provide information about corporations controlling assets in two or more countries. Of the sources listed, only 66 rely on hard-copy reference books while 72 are machine-readable data bases that can be reached from a computer terminal.

Both hard-copy and machine-readable sources monitor news and journal articles about multinational corporations and compile comprehensive reference data. A computer terminal can be used to quickly probe available information and request specific data about the companies listed by any of the machine-readable data bases. In seconds, a computer readout will reveal how many articles deal with the subject in question and provide a brief description of the ones of particular interest. The same research done by traditional methods could take months to complete.

The directory's helpful format enables the user to easily determine which data bases are appropriate for solving particular research problems. The comprehensive listing by each data base brings obscure journal articles to the attention of interested researchers, government officials, corporate officials, librarians, and curious onlookers.

Data for the directory were compiled by contacting data base and information source organizations through telephone calls, mail surveys, and correspondence. A literature search was also conducted at the UIUC Library and the University of Chicago's Regenstein Library. A previous research publication, also prepared under the direction of Williams, *Computer Readable Bibliographical Data Bases — A Directory and Data Source Book,* provides the bibliographical data base listings.

The new directory is in printing and will soon be available from the United Nations. Through multinational cooperation we may soon know more about multinational corporations. ●

TODAY'S WORK IS TOMORROW'S PLEASURE

Remember the wishful predictions you used to hear about some wonderful technological discovery that would provide unending supplies of energy for mankind and eliminate all possibilities of an energy shortage? Don't lose hope. A UIUC Department of Electrical Engineering study could be one of the important links in the chain of developments leading to the use of seawater as an almost endless fuel supply for the production of electricity.

Making the dream come true depends on the development of a nuclear fusion reactor that would produce vast amounts of heat during the nuclear reaction of two hydrogen isotopes found in seawater; the resulting heat energy could easily be converted into electricity. Since hydrogen is a plentiful fuel supply, nuclear fusion is an improvement over energy production by nuclear fission, which relies on the scarce supplies of uranium and plutonium for fuel. But fusion reactors are still a dream because they burn up all of their hydrogen fuel in just a second, leaving engineers with the task of developing a method to refuel the machines with a constant supply of hydrogen.

UIUC professor R. J. Turnbull is pursuing the possibility of using solid pellets of hydrogen isotopes as a continual supply of fuel. His experiments are the first ever attempted to refuel a nuclear fusion machine with pellets and will attempt to increase the reactor's operating time from a mere second to several consecutive minutes.

Through previous experiments, Turnbull has learned that hydrogen pellets are more suitable for future reactors than the commonly used neutral beam of hydrogen, but they must be large enough and propelled fast enough to reach the center of the reaction chamber before they evaporate and become hydrogen ions. At the center of the reaction chamber, the ions would collide with ions of another hydrogen isotope and cause a nuclear reaction that releases heat energy. Those experiments have led him to believe that the hydrogen pellets should be a few millimeters in diameter and propelled at a velocity of about 10 km/sec (62 mi/sec) in order to reach the center of the nuclear reaction chamber.

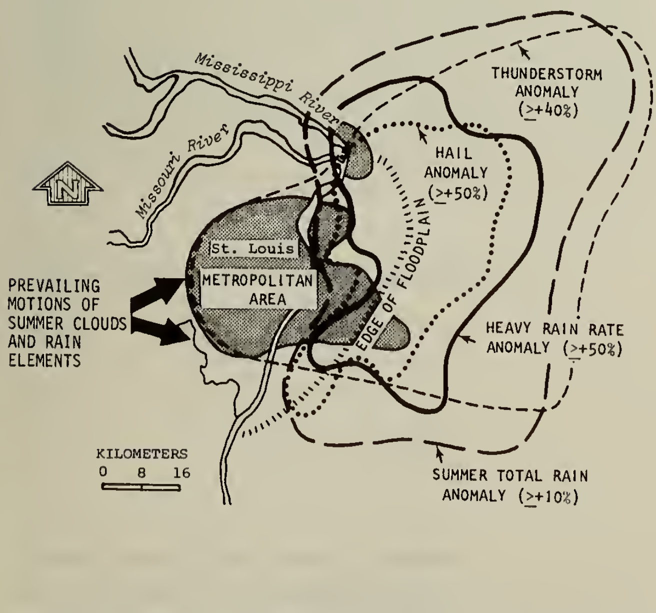
A major obstacle to the experiment's success will be determining a method of accelerating the pellets. Preliminary experiments will use plasma guns to heat one side of each pellet and cause a rocket effect as part of the pellet burns away and accelerates the remainder to a high velocity. The experiments will also test the effectiveness of lasers and ion beams to accelerate the pellets.

If successful, the UIUC experiments would certainly facilitate progress toward the energy dream machine. Sophisticated fusion reactors that would adopt the new knowledge would probably require only 30 years to be developed for actual use. Then, 21st century people could enjoy an abundant supply of electricity, harvested from seawater. ●

CITIES PRECIPITATE BAD WEATHER

If city slickers complain more than rural folks about summer storms, don't blame them. Evidence now indicates that summer weather is indeed more severe in large cities than in the surrounding rural countryside. A recent study of St. Louis shows that the city has more clouds, more rain, more severe storms, longer thunderstorms, and warmer temperatures than the surrounding region and causes similar weather patterns up to 40 km (25 mi) downwind into Illinois.

Results from a five-year study of the St. Louis area, conducted by the Illinois State Water Survey in conjunction with UIUC, indicate that the city causes increased rainfall due to its concentrations of water vapor and dust. Led by William C. Ackermann, chief of the SWS and Department of Civil Engineering professor; Stanley A. Changnon, head of the Atmospheric Sciences Section of the SWS; Richard G. Semonin, assistant head of the Atmospheric Sciences Section of the SWS; and Floyd A. Huff, principal scientist of the SWS; the study concludes that the many particles found in the city atmosphere make nuclei for cloud condensation so readily available that the city's atmosphere produces storms as often in dry periods as in wet periods.


Mississippi River
Missouri River
N
THUNDERSTORM ANOMALY (≥+40%)
HAIL ANOMALY (≥+50%)
EDGE OF FLOODPLAIN
St. Louis
METROPOLITAN AREA
PREVAILING MOTIONS OF SUMMER CLOUDS AND RAIN ELEMENTS
HEAVY RAIN RATE ANOMALY (≥+50%)
KILOMETERS
0 8 16
SUMMER TOTAL RAIN ANOMALY (≥+10%)

This Illinois State Water Survey map of the St. Louis area shows how heavy rains, thunderstorm occurrences, and size of hail are increased in the city and for a short distance downwind into Illinois. A five-year study has concluded that the city environment causes weather to be more severe in St. Louis than in the nearby countryside.

The tiny particles in city air act much like a cloud-seeding operation and, compared to the surrounding region, increase summer rains by 40%, the number of severe storms is doubled, and there is a 60% increase in the number of storms that produce an inch or more of rain. The city also causes an increase in the duration of thunderstorms and increases their frequency. Not only does the study show that rainfall is heavier over the city, but it is also heavier downwind from the city.

Skyscrapers and large buildings have their effects on airflow through the city and surface winds are sometimes affected 4.8 km (3 mi) away. The St. Louis weather study provides evidence that heat and moisture flow upward from city surfaces to cause a 10% increase in summer cloudiness. The rising heat becomes an updraft that pushes clouds to a level 300 to 600 m (roughly 1000 to 2000 ft) higher than nearby clouds. The updraft also keeps hailstones airborne for a greater than usual time span resulting in larger sizes of hail, although hailstorms are no more frequent or prolonged than their rural counterparts.

Researchers found that the temperature in St. Louis averaged 1.7 to 2.8°C (3 to 5°F) warmer than surrounding areas, including a city temperature that averaged 5.6°C higher at night. The city's influence on clouds and rainfall was discovered to be most pronounced during the summer months, specifically between the hours of 2 p.m. to 5 p.m. and 9 p.m. to midnight. The results from the St. Louis study have been so intriguing that researchers have planned a similar study of Chicago to compare weather influences in a landlocked city with those in a city fronting on a large body of water.

Of course the problems associated with severe weather mean the city also experiences more water runoff, more local flooding, more soil erosion and silting, and more water pollution than rural areas. Fringe benefits to nearby agricultural land are demonstrated by a 3 to 7% higher-than-average crop yield due to greater rainfall. Although no scientific judgments should be made in haste, it does appear that the city of St. Louis acts precipitately. ●

McMILLAN WINS FRITZ LONDON AWARD

The world's highest honor for research in very low temperature physics has been presented to William L. McMillan of the UIUC Department of Physics. He was named one of three recipients of the 10th Fritz London Award for his outstanding theoretical contributions to fundamental knowledge about superconductivity. The two other recipients are from Bell Laboratories.

McMillan is the second person from UIUC to win this award, which is given every three years. In 1962, it was given to professor emeritus John Bardeen of the Department of Physics. Bardeen, of course, is renowned as the only person to receive two Nobel Prizes in the same field.

The 1978 award was presented to McMillan at the 15th International Conference on Low Temperature Physics in France. McMillan is currently on sabbatical leave from UIUC and is working at the University of Orsay, France. ●

PEOPLE AND PLACES

Roger A. Strehlow, Department of Aeronautical and Astronautical Engineering, has been appointed chairman of the panel on causes and prevention of grain elevator explosions of the National Research Council. The panel reviews information about recent major grain elevator explosions and provides conclusions regarding their occurrence. Strehlow has served on the council's committee for evaluation of industrial hazards since 1976.

Charles P. Slichter has been renominated by President Carter to serve a six-year term on the National Science Board. A member of the UIUC Department of Physics since 1959, Slichter was appointed to the National Science Board in 1975 to fill an unexpired term.

Arthur L. Friedberg, head of the UIUC Department of Ceramic Engineering since 1963, has been named executive director of the American Ceramic Society. He will retire from UIUC to accept the position at the society's Columbus, Ohio, headquarters on January 1, 1979, where he will lead the professional organization's 10,000 members in the U.S. and a dozen other countries.

The fourth **Tykociner Memorial Lecture** was recently delivered at UIUC by **Sol Spiegelman**, director of the Institute of Cancer Research and professor at Columbia University. The internationally known biologist was a member of the UIUC faculty from 1949 to 1969. The biennial Tykociner Memorial Lectures honor Joseph T. Tykociner, a UIUC faculty member who gained fame for his invention of sound-on-film movies in 1922 and other distinguished work in electronics.

The American Society of Civil Engineers has awarded its highest honor to **Chester P. Siess**, professor emeritus and past head of the UIUC Department of Civil Engineering. Siess has been named an honorary member of the society.

The Edison Electric Institute has awarded its Distinguished Power Education Citation to **M. Stanley Helm**, Department of Electrical Engineering, "for long-standing and unique dedication to electric power engineering education, for the inspiration provided to students, and for engineering contributions to the electric power industry." ●

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inside outlook:

A DATING METHOD FOR ARCHAEOLOGICAL CERAMICS
BIONICS DEVELOPS CREATIVE POTENTIAL OF ENGINEERING STUDENTS
JOHN FRITZ MEDAL AWARDED TO ILLINOIS PROFESSOR
NEW HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING NAMED

THE DATING GAME IS NOT THE SAME

A new method of dating ancient relics could outdate present methods of determining the age of artifacts. Researchers at the University of Illinois at Urbana-Champaign are testing the possibility of establishing the age of ceramic objects by measuring the small amount of natural radiation damage that occurs at a fixed rate to quartz crystals which are present in fired ceramic material in varying degrees. The new dating method is called electron paramagnetic resonance (EPR) dating.

Under the supervision of professor Wendell S. Williams of the Departments of Ceramic Engineering and Physics, Christopher Maurer, a doctoral candidate in ceramic engineering, is studying the feasibility of EPR dating. The new method offers potential because of its distinct advantages over the thermoluminescence dating technique for ceramics currently used by archaeologists.

Since the majority of artifacts recovered at archaeological sites are nonorganic, carbon-14 methods are limited because they can date only organic material. The principal current method for determining the age of archaeological ceramics, thermoluminescence, has a major disadvantage: it can be used only once per sample because it destroys the evidence of age during the measurement process.

Like thermoluminescence, EPR dating determines the age of nonorganic material by assessing the effect of the small amount of natural radiation that a ceramic object has absorbed from the time it was last fired, but EPR dating does not destroy the evidence of age. Both techniques exploit the fact that natural quartz generally has an aluminum impurity that traps electrons knocked loose in the quartz by natural radioactivity. The procedures differ in the way the amount of radiation damage is measured. In the thermoluminescence process, a small sample of the artifact is heated, releasing electrons from the traps in the quartz. The subsequent recombination of the electrons with holes emits light proportional in intensity to the total radiation absorbed. But once the electrons have been released, the sample can never be used again to retest the object's age. EPR dating leaves the electron record of natural radiation absorption intact since the object is not heated. Instead, the number of trapped electrons is measured by a spectrometer that responds to their magnetic properties.

Previous research on EPR dating has been thwarted by the fact that the signal from such a small amount of radiation damage is very weak and difficult to measure, but that problem has been overcome at UIUC. The same experiment is repeated 100 times, and the weak and noisy signals are detected by a spectrometer and stored in a signal averaging computer. After many repetitions of the experiment, the signal averager is able to cancel out images made by random noise and plot the increasingly vivid periodic pattern from the damage center. The year the ceramic object was made can then in principle be established by correlating the peak height of the signal with the rate that quartz absorbs natural radiation.

In preliminary research, the EPR method has accurately measured the amount of radiation damage in quartz in a laboratory situation that simulates the amount of natural radiation a ceramic pot would receive in about 200 years. The signal gets stronger with increasing total exposure. The true test of EPR's usefulness as a dating method will occur in the second stage of research when the age of ancient Grecian and Philippine pottery fragments will be determined and compared with the objects' known age. At that time, a new research method may be born that could be used in the future to unravel the story of the past. ●

NATURE WAS CREATED WITH DESIGN INSPIRATION

"If man were meant to fly he would have been born with wings," or so the saying goes. Although man doesn't have wings, he does have creativity and the ability to adapt natural phenomena into mechanical devices. Nature inspired development of the fantastic flying machines, but it takes a keen eye to notice that most of the physical laws that man has developed into engineering disciplines are illustrated in nature.

For the many engineering problems facing man, there's often a counterpart in nature where the problem has already been solved, asserts professor D. H. Offner in his introduction to bionics class at the University of Illinois at Urbana-Champaign. Offner defines bionics as the study of living systems for engineering adaptations. He believes bionics can be a valuable aid in developing the design and creative potential of engineering students and asks them to observe, analyze, and translate nature's means of solving specific problems into engineering designs that might solve human problems.

Students have been inspired by previous engineering adaptations of features found in living systems, such as the thermoscopic vision of snakes that detects temperature changes as small as 0.001°C. Researchers of bionics translated the snake's temperature-detecting ability into engineering terms, making infrared photography possible. Two other examples from the long list of machines which resulted as adaptations from nature include commercial chemical light devices, inspired by the firefly's chemical mechanism for generating cool light, and an electronic eye for detecting motion, patterned after the frog's eyes which can sort out movements.

Other bionics projects being studied elsewhere include analysis of the unique body shape of whales, a design which requires only small amounts of energy for propulsion. If adapted to boats, the whale-shape could result in a 25% reduction of power requirements without reductions in speed or cargo weight. Another bionics project is the flapping-wing propulsion system in insects, which has potential for improving aircraft.

Offner has begun his own modeling of insects by studying the biological findings that are relevant to engineering. From a choice of more than 80,000 varieties of two-winged flies, each with modifications in basic design, Offner decided to build a large-scale wing mechanism of the flesh fly, in terms of engineering design.

The resulting adaptation of the flesh fly mechanism is a model which Offner describes as a double space-toggle mechanism with flexible supports. Unlike the fly, which has a cruising speed of 180 body lengths per second and a wing flapping rate of 200 cycles per second, the model is incapable of flight and merely shows how the flying system would operate. The space-toggle synchronizes the wing speed on both sides of the thorax with an almost frictionless toggle mechanism that allows the distance between the wings to vary so that turning is possible when the amplitude of the beating wings is allowed to become unequal.

In his bionics research, Offner has found that the taxonomy classifications of plants and animals which biologists base on similarities in form, are of little use in the functional applications that interest engineers. He has proposed that an engineering classification scheme, based on functional rather than structural similarities, be used as a guideline in the study of bionics. The example shown illustrates how the flesh fly is classified by biologists and how, for purposes of comparison, a gear reducer might be similarly classified by engineers.

Form Taxonomy Classification of a Flesh Fly		Functional Taxonomy Classification of a Single Stage Gear Speed Reducer
Name	Category	Name
Animal	Kingdom	Rotating System
Arthopeda	Phylum	Rigid Body Mechanics
Insecta	Class	Packaged Separately
Ptergeta	Subclass	Fixed Gear Ratio
Diptera	Order	Single Stage
Sarcophagidae	Family	Parallel Shafts
Sarcephaga	Genus	Winsmith Model
Bullata	Species	No. 700

As further study of living systems is made by aspiring engineers, highly conscious of nature as a vast source of information, bionics will continue to be highly regarded as a source of inspiration for engineering design. ●

NEWMARK RECEIVES HIGHEST ENGINEERING HONOR

Civil engineering professor emeritus Nathan M. Newmark has been named the 1979 recipient of the John Fritz Medal, the highest honor of the engineering profession. The award is sponsored by six professional engineering societies.

Newmark joined the UIUC faculty in 1930, headed the Department of Civil Engineering from 1956 to 1973, and retired in 1976. He has made outstanding research contributions in many areas of structural and foundation engineering.

He is the second person from UIUC to receive the John Fritz Medal. In 1937, it was presented to the late Arthur Newell Talbot, also a civil engineer. ●

SWENSON TO HEAD ELECTRICAL ENGINEERING

Distinguished radio astronomer George W. Swenson, Jr., will become head of the UIUC Department of Electrical Engineering in August 1979 when the current head, Edward C. Jordan, retires. The appointment was recently approved by the University's board of trustees.

Swenson has been a faculty member in the UIUC Departments of Astronomy and Electrical Engineering since 1956 and from 1970 to 1972 was acting head of the Department of Astronomy. Next summer he will become head of the largest department on the UIUC campus and the largest electrical engineering department in the United States. Current enrollment in the department includes 1,488 undergraduates and 283 graduate students.

Swenson received engineering degrees from Michigan Technological University, Massachusetts Institute of Technology, and the University of Wisconsin. Among the many accomplishments of his distinguished career are directing engineering at the National Radio Astronomy Observatory and planning the Very Large Array, the world's largest radio telescope now being built near Socorro, New Mexico.

He has been technical director of the committee on telecommunications of the National Academy of Engineering and was instrumental in establishing the UIUC Vermilion River Observatory, which he directs. His activities at UIUC have also included pioneer work in the use of earth satellites for research on the ionosphere.

Edward C. Jordan is now in his 25th year as head of the Department of Electrical Engineering and has been a UIUC faculty member since 1945. ●

LINCOLN AWARD TO ILLINOIS

For the eleventh time in eleven years, engineering students at the University of Illinois at Urbana-Champaign have won a prize in the undergraduate division of the Lincoln Arc Welding Foundation engineering design competition, which involves engineering colleges nationwide.

The 1978 second place award was won by a team of four general engineering students who will share the $750 prize. The UIUC Department of General Engineering has also received $250 and a plaque from the Lincoln Arc Welding Foundation.

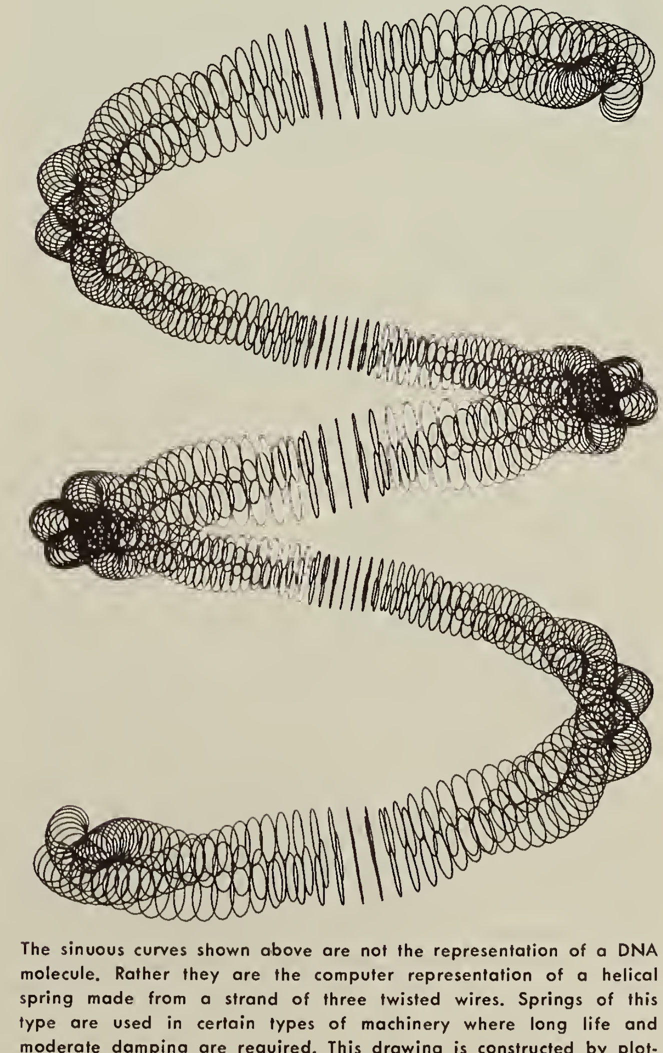
Student members of the winning team in the national competition are Steven D. Rak, John A. Notardonato, David H. Coyle, and Gary H. Steere. All were seniors last year and are now employed in engineering jobs. UIUC faculty advisors were professors Rodney D. Hugelman and S. A. Ramamurthy, both of the Department of General Engineering.

The UIUC entry was a two-way weld positioner, a device for welding plates as large as 31 by 42 feet in size with welds up to 42 feet long. Entries were judged for originality, ingenuity, feasibility, and engineering competence. ●

SCHOLARLY BIRTH

A student bioengineering organization is being planned at UIUC with the possibility of becoming the first student chapter in one of the several national professional societies in bioengineering.

UIUC has been the birthplace of a dozen or more professional and honor societies which are now nationwide, including Eta Kappa Nu, the electrical engineering honor society founded at UIUC in 1904. ●



The sinuous curves shown above are not the representation of a DNA molecule. Rather they are the computer representation of a helical spring made from a strand of three twisted wires. Springs of this type are used in certain types of machinery where long life and moderate damping are required. This drawing is constructed by plotting, in a true three-dimensional sense, the cross sections of the wires in the strand at consecutive locations along the spring. An analytical study of the mechanical response of stranded wire helical springs is being conducted by professors George Costello and J. W. Phillips in the Department of Theoretical and Applied Mechanics.

PEOPLE AND PLACES

William D. O'Brien, assistant professor of bioengineering in the UIUC Department of Electrical Engineering, has been elected to the American Institute of Ultrasound in Medicine (AIUM) Board of Governors. With more than 3,000 members, AIUM is the world's largest organization dealing with both the basic and applied use of ultrasound in clinical medicine.

The American Academy of Environmental Engineers has invited professor **Ven Te Chow** to become a diplomate, following nomination by the American Society for Engineering Education. Chow has been a member of the UIUC faculty since 1948 and is internationally known for his work in hydraulic engineering and in water resources planning and development.

Daniel Alpert has been named a member of the National Research Council's Commission on Sociotechnical Systems. The UIUC professor is director of the Center for Advanced Study and associate director of the Computer-based Education Research Laboratory. The Commission on Sociotechnical Systems guides National Research Council undertakings concerned with the application of large technological systems such as transportation, building technology, and materials.

Egyptian prime minister **Moustafa K. Khalil,** who has been active in middle-east peace negotiations, is a College of Engineering alumnus. Khalil received a master's degree from UIUC in 1948 and a doctorate in civil engineering in 1951. ●

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inside outlook:

A COMPUTER CAPABLE OF CONVERSATION
DETERMINING VIRAL RESISTANCE TO CHLORINE
TACONITE'S ADVANTAGES IN IRON PRODUCTION
EDUCATIONAL PLAN FOR MINORITY STUDENTS
ENGINEERING OPEN HOUSE 1979

"IS THIS WHAT YOU MEAN?" WROTE THE MACHINE

Aside from the occasional cartoon character, few people find it productive to talk to a brick wall. At the University of Illinois at Urbana-Champaign, though, people are spending a lot of time conversing with a machine. However, unlike the brick wall, their machine — a computer — is writing answers back in conversational English.

The two-way communication between man and machine is made possible by a system, being developed for the Office of Naval Research, called PLANES (Programmed LANguage-based Enquiry System). The purpose of the system is to make the information stored in computer banks easily accessible to those who have no training in the technical operation of computer terminals.

The PLANES system is being developed by professor David L. Waltz of the UIUC Department of Electrical Engineering and the Coordinated Science Laboratory, along with graduate students Bradley Goodman, Harry Tennant, and Timothy Finin. The system's main function will be to provide answers to questions about aircraft flight and maintenance records, but it could be applied to other data bases as well.

PLANES's ability to understand requests typed in English and to respond in kind is accomplished by breaking an input request into phrases and using the information in these phrases to fill in empty "slots" in a formal data base query template. These slots require information about which files to search, what kinds of items to return as an answer, what the restrictions are for a particular item to be part of the answer, and so on. Often PLANES must look at earlier parts of the conversation or use general knowledge to find all the information it needs to fill in the slots.

When PLANES has evaluated the question, it responds with answers in the form of graphs, tables, or lists which are typically presented at the terminal within 10 seconds from the time the user finishes a written request.

Not only can the system reply swiftly in conversational language, but it has a tolerance for errors as well. For instance, the system corrects spelling errors and accepts a wide range of nongrammatical requests. When human error is encountered, PLANES feeds back to the user a grammatically correct paraphrase of the request to allow the operator to verify that the request was understood. The operator's inquiry, "Which Skyhawks logged less than 10 hours between January 1 and Jule 1 '73?" causes PLANES to respond, "I don't know the meaning of Jule, perhaps it's misspelled? Please enter a number corresponding to the following: 1. June 2. July 3. None of the above." The operator replies, "2," PLANES writes back, "OK," and the operator's request for information can continue.

PLANES also answers questions that leave out information discussed earlier in a conversation. An example of this feature starts with the question, "How many flights did the A7 with tail number 003 make in January, 1973?" PLANES answers "17." The operator continues questioning with, "March?" PLANES is able to understand that the question is really, "How many flights did the A7 with tail number 003 make in March, 1973?" The machine correctly tabulates the answer and responds, "13."

When operational, the system will also have the ability to store conversations for future reference, in effect remembering previously asked questions. The user might state, "A while ago we were talking about Skyhawks," and PLANES will be able to formulate answers about Skyhawks that deal directly in the time frame and context that the operator was using before changing subjects. When the operator has trouble using PLANES correctly, the machine responds automatically with help files to explain procedures that will enable the user to gain the most productive use of PLANES data. The result does not make the sophisticated machine as intelligent as man, but it does make an ordinary man as powerful as a machine. ●

THE SOLUTION IS THE PROBLEM

You've probably seen many cartoons depicting a weary prospector lost in the hot desert, crawling on hands and knees in a desperate attempt to reach a water hole for a life-sustaining drink of water. Barely making it to the brink of the pond, he cups his hands and reaches past sun-bleached bones guarding a rickety old sign that might read, "Danger, polluted with virus."

It is a grisly situation for the prospector, but fortunately for us, modern water supplies are processed by a purification system including treatment with chlorine to disinfect the water and make it potable. However, recent information suggests possible disadvantages that might derive from the use of chlorine. A potential problem could be that chlorinated hydrocarbons, formed by a reaction between chlorine and organic matter in water, may actually be carcinogens.

Engineers are presently seeking alternatives as effective as chlorine for water disinfection. For purposes of comparison, a three-year study by the UIUC Department of Civil Engineering under the direction of environmental and civil engineering professor R. S. Englebrecht, in collaboration with professor Michael Weber of the Department of Microbiology, has been completed which provides an accurate data base showing the effectiveness of chlorine. The effectiveness of potential substitutes for chlorine will be compared with the results of this study to ensure equal standards of disinfection will be maintained or even improved if a new disinfectant needs to be adopted.

Viewed under an electron microscope, these poliovirus globlets are one of six enteric viruses studied by UIUC researchers to establish standards of virus resistance to chlorine. These standards of effectiveness will be used to compare the effectiveness of other disinfectants that could potentially be substituted for chlorine in public water supply treatment plants.

The UIUC study focuses on the effectiveness of chlorine against a wide range of enteric viruses. These viruses, which originate in human intestinal tracts, become a part of the wastewater that is eventually recycled into rivers and streams which are a source of drinking water for the communities located along the stream's flow.

The six enteric viruses selected for study represented those regarded as least resistant and most resistant to chlorine disinfection. They were all cultured in the same way before being subjected to the carefully controlled conditions of the experimental system. The precise results of the research show the time required to inactivate 99% of the viruses contacted by chlorine. The six viruses had significantly varied resistances to chlorine under different conditions of temperature and pH. A significant observation is that the time required for 99% inactivation is different for each of the six viruses, even when subjected to identical disinfection conditions.

The exact measurements of chlorine's effectiveness against the wide range of enteric viruses are standards that substitute disinfectants will aim to match or better. Englebrecht is also working on another study that is testing the use of ozone as an alternative disinfectant. Preliminary results have been encouraging.

Since chlorine became popular as a water supply disinfectant 50 years ago, signs of virus pollution causing infection through water have nearly disappeared. But like the thirsty prospector who found the watery solution to his life-or-death problem to be a deadly problem in itself, science has found that chlorine's solution to disease-causing viruses may be a disease causer in itself. ●

IRONIC SUPERIORITY

A research project initiated at the University of Illinois at Urbana-Champaign has ironed out some misconceptions about the values of iron mining procedures by showing that a man-made pellet of concentrated iron ore is really a ball of energy filled with cost savings compared to naturally concentrated iron ore. Low-grade taconite, once thought to be valueless, has proven to be the most desirable form of iron ore when mechanically converted into marble-size pellets. The pellets have lowered the cost of molten iron production by reducing labor costs and conserving energy.

The study by professor Peter J. Kakela, under the direction of professor Bruce Hannon of the UIUC Energy Research Group, compares the expenses incurred while producing bars of pig iron from high-grade iron ores containing as much as 65% iron, with those of low-grade taconite ore containing less than 30% crude iron.

The study's historical analysis of iron production shows that mining companies were forced to develop taconite ore mines when it was realized in the early 1950s that supplies of high-grade iron ore were becoming depleted. In 1955, a commercialized process for converting the taconite into marble-size pellets was introduced. The process required that mills be built near the taconite mines to crush the ore, magnetically separate the iron, and mechanically concentrate the ore into marble-size pellets containing 65% iron before being shipped to blast furnaces.

Pelletization made taconite mining feasible but mining of high-grade ore was still looked on as the preferred method because it could be mined and shipped without preparation. Even though taconite ore undergoes a chemical change during the baking stage of the pelletization process that contributes 37% of the total energy needed to make the pellets, the UIUC study shows that preparation of taconite pellets requires six times the amount of energy per ton as the preparation of naturally concentrated iron ore.

Preference for high-grade iron ore has proven to be a misconception, however, because the superiority of taconite pellets becomes evident at the blast furnaces where advantages in labor and energy savings are substantial and more than make up for the extra energy cost required for pellet preparation. By increasing the chemical efficiency of blast furnaces, taconite pellets reduce the total amount of energy needed for the production of molten iron by 17%. The uniform size and shape of the pellets result in greater permeability, increase the gas/solid contact ratio, and reduce the amount of time needed to melt the pellets, as compared to naturally concentrated ore. The high-grade ore is softer than taconite and fragments into tiny particles of uneven shapes and sizes that tend to clog blast furnaces and inhibit their efficiency.

By 1975, 80% of the iron ore shipped to blast furnaces was in the form of taconite pellets, but the reasons for their popularity is changing. Initially, the steel industry favored taconite pellets because the increased productivity at the blast furnaces meant the number of man-hours per net ton of molten iron, at the mine and blast furnace combined, was decreased by 8.2%. Since then, energy costs have become more important and the UIUC study's documentation of energy savings with taconite pellets makes them an iron-clad investment. ●

PRINCIPALLY SCHOLARS

Minority students enrolled at universities, particularly in engineering programs, are distinctly in the minority. However, the number of minority students preparing for careers in science and engineering is increasing due to a unique program introduced at seven inner-city Chicago high schools three years ago by the UIUC College of Engineering. Eight high schools have now adopted the action plan, called the Principal's Scholars Program (PSP), seeking to heighten minority student interest in science, mathematics, English, and foreign languages in an effort to adequately prepare the students for post-secondary education in any curriculum at a college of their choice.

The broadly-based educational plan does not limit students to study in engineering; instead, it prepares minority students for a wide range of academic choices. Individual minority students with academic potential are selected as members of the PSP by their high school while in the eighth or ninth grade. To be a privileged PSP member, the student must agree to take four years of mathematics, three years of science, four years of English, and two years of a foreign language, in addition to the high school's own requirements. In an effort to foster pride in the program, the high schools limit membership to 50 minority students per grade at each of the participating schools.

Although the College of Engineering launched the program and provides incentives to motivate the 1200 minority students who are currently active members of the PSP, leadership is provided by the principals and administrators of the schools where the PSP students are enrolled. The role of the College of Engineering is to provide course improvement assistance, program evaluation, teacher and counselor enrichment, special event support, and awards and recognition.

The program's motivating force includes peer support, involvement, and natural pride in achievement. High interest in the program has been developed through academic tests and competitive engineering contests between PSP students at rival high schools. Distinctive PSP logotypes are available to members and are attractively worn on T-shirts and displayed on folders, pins, decals, and many other items.

In a continuing effort to promote academic excellence, the program involves group members in field trips to industrial facilities, attracts outside speakers to present engineering orientations and career perspectives, and motivates students to participate in summer programs, such as the two-week Minority Introduction to Engineering (MITE) program, at UIUC or other midwestern schools. Additional skills are provided by workshops in computers and other subjects designed to enhance academic performance at universities. With support from parents and high school administrations, PSP students are striving for a wide range of educational goals with increased enthusiasm. Although the Principal's Scholars Program provides a flexible educational base, it does not guarantee the student admission to UIUC or any other college, but it does ensure a promising future for the many PSP graduates who will enroll at colleges for the first time next fall. ●

ENGINEERING TARGET: TOMORROW

Thousands of spectators are expected to attend the 1979 Engineering Open House March 9-10 at the College of Engineering on the UIUC campus. The theme of this year's student-run show is "Engineering Target: Tomorrow."

All departments and student engineering societies from the College will be involved in engineering demonstrations that display scientific principles and current research. Special attractions at this year's show include a display of the wonders of chemistry — Dr. Haight's Magic Show — and a demonstration of flight principles — Snoopy's Flying Doghouse. An event of special interest during the EOH weekend will be an engineering debate matching students from UIUC against students from the Massachusetts Institute of Technology.

Engineering Open House is of particular interest to high school students interested in the opportunities engineering offers. A two-day program for high school juniors and seniors will be conducted in conjunction with the Engineering Open House.

Engineering Open House is totally organized and operated by the students of the UIUC College of Engineering. Engineering Council is the student organization responsible for the event. Everyone interested in engineering is invited to attend. For more information contact 300 Engineering Hall, University of Illinois at Urbana-Champaign, Urbana, IL 61801. ●

PEOPLE AND PLACES

Aeronautical and astronautical engineering professor **Kenneth R. Sivier** has been appointed associate fellow in the American Institute of Aeronautics and Astronautics.

Professor **Robert W. Bohl** has been named a fellow of the American Society for Metals, an honor which goes to less than 1% of the members in this society. He has been a member of the UIUC Department of Metallurgy and Mining Engineering since 1946.

Professor **Martha E. Williams**, of the UIUC Coordinated Science Laboratory, has been appointed to serve on the Board of Regents of the National Library of Medicine, an organization of the National Institutes of Health.

Professor of aeronautical and astronautical engineering **Charles E. Bond** has been appointed technical adviser to the U.S. Department of Energy. He will serve as a technical reviewer of proposals for the Midwest Appropriate Technology Grant Program.

The director of the UIUC Highway Traffic Safety Center, **John E. Baerwald**, was one of four delegates representing the United States at a December 1978 meeting of transportation leaders and urban planners from 20 countries meeting in Tel Aviv, Israel. Baerwald is past president and director of the International Institute of Traffic Engineers. ●

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COLLEGE OF ENGINEERING
VOL. 20, NO. 7, MARCH 1979

inside outlook:

THEORIZING THE ORIGIN OF ACOUSTIC GRAVITY WAVES
UIUC RANKS HIGH IN SURVEY OF ENGINEERING FACULTIES
FINDING A CHEMICAL ADDITIVE FOR COAL GAS
UIUC LEADS NATION IN ENGINEERING GRADUATES
MODELING ENVIRONMENTAL IMPACT OF COOLING TOWER PLUMES

CASE OF THE TURBULENT WAVE

You may remember from the golden age of radio that only the Shadow knows what evil lurks in the minds of men. But even with the greatest detective skills, the Shadow didn't know what mysterious phenomenon caused your radio to fade in and out during the program if it was broadcast from a far distance.

For many years engineers have known that, as sky waves, radio waves can be broadcast a great distance by reflecting off the ionosphere. However, the reflected radio waves are often disrupted by ionospheric disturbances caused by events that still puzzle engineers.

A UIUC research project by professors K. C. Yeh and C. H. Liu of the Department of Electrical Engineering involves the investigation of acoustic gravity waves, an alleged inducer of ionospheric disturbances. The existence of these invisible waves has been detected since the early part of this century, but no one knows what causes them.

What little is known about acoustic gravity waves indicates they are ordinary mechanical waves driven by pressure and buoyancy, causing them to ascend with increasing velocity to the upper atmosphere. These waves have been observed nearly all the time in all height regions of the atmosphere including ground level, but are extraordinary because their amplitude grows nearly exponentially with increases in altitude.

Although they have been most easily observed following nuclear explosions in the atmosphere, current theories suggest the waves occur from everyday natural causes such as thunderstorms, winds, and changes in temperature. Instabilities associated with these natural events are believed to generate acoustic gravity waves and set them in motion, propagating them upward throughout the atmosphere. As they travel, they transfer an appreciable amount of energy and momentum that might be related to the dynamics of weather systems.

The consequences of acoustic gravity waves become more apparent when they reach the upper atmosphere. Here, the momentum is forceful enough to create ionospheric disturbances that disrupt the otherwise mirror-like layer of ionized particles that reflect radio waves, such as broadcast radio waves from short-wave stations like the *Voice of America* or those used for point-to-point navigational purposes. When the ionosphere is disrupted, radio waves are reflected unevenly and fading of the broadcast signal occurs, as well as errors for navigators who rely on smooth reflected radio waves for determining locations.

The UIUC research project hopes to add information to the knowledge of acoustic gravity waves that will create an understanding of how these mysterious waves originate. Some of today's most sophisticated equipment will be used to gather information from heights as high as 1000 km (600 mi). The world's largest radar unit, at Arecibo, Puerto Rico, will be used to probe the ionosphere in an effort to track the propagation effects of acoustic gravity waves. Because the radar energy scattered back from the atmosphere will be very small, the large radar is needed to produce observable results. In addition, highly sophisticated VHF radar instruments provided by the Max Planck Institute for Aeronomy in West Germany will be used to study lower regions of the atmosphere.

In cooperation with the Arecibo observatory and the Max Planck Institute for Aeronomy, the UIUC researchers will use the radar data to interpret the dynamics of acoustic gravity waves and their interactions with the ionosphere. It is hoped that the data can be used as a basis for developing a theory on the origin of acoustic gravity waves and how the propagation of these waves transfers momentum that sets atmospheric systems in motion. It's a sky high mystery that often preempted even the Shadow, but with modern technology, the UIUC researchers might solve the case. ●

FACULTY AMONG "MOST DISTINGUISHED"

The faculties of the College of Engineering and the Department of Physics received high marks in a survey of 19 academic disciplines reported in the January 15, 1979, issue of *The Chronicle of Higher Education*. The survey, conducted by Everett C. Ladd and Seymour M. Lipset in 1977, asked more than 4000 faculty members of four-year colleges and universities to "name the five departments nationally in your discipline which have the most distinguished faculties," in rank order.

The UIUC College of Engineering faculty was named as one of the top five by 44% of those responding in the field of engineering. Ten percent felt that the UIUC engineering faculty was the best in the nation. Only three schools, Massachusetts Institute of Technology, Stanford University, and the University of California, Berkeley, were listed more often than UIUC. Physics was evaluated as a separate discipline. The UIUC physics faculty was numbered among the top five by 24%; it was seventh overall.

The University of Illinois at Urbana-Champaign as an institution fared very well. At least 10% of the respondents felt that UIUC was among the top five in 11 of the 19 disciplines surveyed. ●

EMENDING EMISSIONS

There was a time when chimney sweeps were needed to clean the soot out of chimneys dirtied by thick, black clouds of pollution particulates formed during the combustion of coal. It wasn't until about 100 years ago that engineers cleaned up the situation by developing ways to convert coal to a gaseous form that could be burned without emitting billows of particulate matter.

But before coal gas had time to be adopted for use, oil and natural gas were discovered and quickly became popular heating fuels that eliminated the need for coal gas. Now that the supplies of these easy-to-use fuels are diminishing, America's 600-year supply of coal is becoming more attractive, and coal gas is once again a popular idea.

Coal gas is relatively simple to produce by injecting steam and oxygen into a chamber filled with coal. This produces an oxidation reaction that converts the coal into hydrogen, carbon monoxide, carbon dioxide, and methane. In the form of gas, coal can easily be distributed to homes through existing natural gas pipelines, thus eliminating the messy handling and storage problems previously experienced with solid coal.

The gasification process also eliminates three of the four pollution problems associated with coal combustion. First, the trace metal pollutants are left as residue in the gasification chamber during the steam injection process. Second, the highly regulated sulphuric oxide pollutants of coal combustion can be easily removed just after the gasification process. Finally, when coal is burned as a gas rather than as a solid, particulate levels are much lower. However, the one significant problem that keeps coal gas from being the easy answer to the energy shortage is also the one remaining air pollution problem that conversion of coal to gas does not resolve. The nitrogen organically bound in coal generally combines with hydrogen and carbon during the coal gasification process to form two highly corrosive and toxic compounds: hydrogen cyanide and ammonia. During subsequent combustion of the coal gas, these compounds efficiently react to form the oxides of nitrogen, which are some of the most stringently regulated of all air pollutants.

A UIUC research effort in the Department of Mechanical and Industrial Engineering, under the direction of professor R. D. Matthews, aims at solving the problem by developing a chemical process to control the nitrogenous products in coal gas. The process would alter the chemical compositions before coal gas combustion so that the emissions would be harmless molecular nitrogen instead of the dangerous oxides of nitrogen.

A chemical kinetics computer program will be used to predict the most suitable substances to promote formation of molecular nitrogen before coal gas combustion. Molecular nitrogen is very stable, with less than 1% conversion to the oxides of nitrogen during combustion. Highest consideration will be given to substances that do not decrease the amount of energy that can be liberated from coal gas. Preliminary studies suggest that nitric oxide, oxygen, water vapor, or ozone could each be a successful stimulus to convert the nitrogenous compounds in coal gas to molecular nitrogen.

The final phase of the investigation is designed to quantify the most efficient ratio of coal gas to the additive that results from the research. The concentration selected for the additive will need to produce an efficient chemical reaction without decreasing the energy content of coal gas. In two years, final results of the research may be available for public utilities to adopt.

The energy shortage has unquestionably brought sweeping changes to America's lifestyle. But if the air pollution problems associated with coal gas combustion can be cleaned away, it will make our energy problems as outmoded as chimney sweeps. ●

UIUC LEADS NATION IN ENGINEERING GRADUATES

A national survey by the Engineering Manpower Commission shows that more engineers received degrees from the University of Illinois at Urbana-Champaign in 1977-78 than from any other school in the United States.

UIUC conferred 1442 engineering degrees including 965 bachelor's, 386 master's, and 91 doctorates. The number of engineering bachelor's degrees conferred at UIUC was also the highest among the 287 universities included in the survey published by Engineers Joint Council.

The universities ranking closest to UIUC for number of engineering degrees conferred were Purdue with 1286, Massachusetts Institute of Technology, 1270; University of Michigan, 1257; and University of California at Berkeley, 1256. ●

TOWER OF CONTENTION

Enormous is a good description of power plant cooling towers, in reference to both their gigantic size and the potential impact they could cause to the surrounding environment. An ongoing UIUC research project shows how cooling tower systems can be environmentally acceptable when properly designed for a specific location.

Built to release the waste heat resulting from production of electricity, these huge towers are often the size of a football stadium at the base and reach heights equivalent to a 50-story building. The hyperbolic shape narrows from about 150 m (500 ft) in diameter at the base to about 70 m (230 ft) in the middle and then increases to about 100 m (330 ft) at the top where water vapor plumes spew into the air and occasionally produce man-made clouds several miles long in cold climates.

Cooling towers are needed at power plants, in addition to the smaller stacks that emit by-products of fuel combustion, because the plants can use only 30–40% of the heat produced to generate electricity. The remainder is waste heat and must be discarded. Historically, the waste heat has been discharged directly to a nearby body of water in what is known as open-cycle cooling, but as more and more power plants are built, the number of ecologically safe locations for open-cycle plants diminishes.

As a last resort, power plants use cooling towers to reject the excess heat into the atmosphere, but criticism and controversy has erupted where cooling towers have been built without adequate regard for the environment. Under certain climatic conditions, adverse environmental effects such as fog and overcast skies can cover the area under the plume. The moist, warm air in the plume has been accused of mixing with pollutants from the plant's emission stacks to form contaminant particles that become deposited on the ground. Another potential problem is the formation of sulphuric acid when the water vapor mixes with gases from the stacks and falls to the ground in the form of an acid rain. In cold climates, the moisture from cooling tower plumes has been known to cause a continual freezing rain near the tower, creating buildups of ice on vegetation.

The UIUC Department of Mechanical and Industrial Engineering research project, under the direction of professor W. E. Dunn, is being conducted to develop mathematical models that will predict the adverse environmental impact cooling towers would be expected to cause if they were built at particular geographic locations. The main goal of the research is to establish prediction schemes for plume behavior and drift deposition patterns.

The analysis of data from existing power plants has determined a consistency of plume and deposition behavior under a variety of temperature and atmospheric conditions. The analysis has been incorporated into mathematical simulations to predict what plume and deposition patterns would be under these various weather conditions at a given plant site.

The ongoing research information is useful to government regulatory agencies and local government groups who must decide on the suitability of a construction site for a proposed power plant. The mathematical models have shown that each proposed power plant site is so different that what is acceptable at one site may not be environmentally safe at another location where weather conditions are slightly different. By showing how the cooling tower vapor would affect the environment at each specific site, the UIUC research information provides the decision makers with basic facts needed to reach a sound conclusion before any of the construction sites are approved or prohibited. It's an early means of preventing what could be an enormous problem. ●

When large bodies of water are unavailable, cooling towers are necessary to reject the excess heat power plants produce while generating electricity. As shown, water vapor pours out from the towers in the form of plumes that can extend for several miles. To make it possible for new power plants to be located at sites where environmental impact will be minimized, UIUC researchers have determined the environmental effects cooling tower plumes will cause under various climatic conditions.

DEPARTMENT HEAD NAMED FOR CERAMIC ENGINEERING

Professor Clifton G. Bergeron has been named head of the Department of Ceramic Engineering, succeeding professor Arthur L. Friedberg who retired January 1 to become executive director of the American Ceramic Society.

Bergeron has been a faculty member at UIUC since 1957, and received the College of Engineering's Everitt Award for teaching excellence in 1975. With his graduate students, he has authored more than 50 research papers and is a fellow of the American Ceramic Society. After receiving bachelor's, master's, and doctoral degrees from UIUC, Bergeron was employed with A. O. Smith Corporation and Whirlpool Corporation before launching his university career. ●

PEOPLE AND PLACES

Nancy J. Hillman, a senior in the Department of Civil Engineering from Palos Heights, Illinois, has received the seventh annual Grace Wilson Award from the Champaign County Chapter of the Illinois Society of Professional Engineers to recognize her as the outstanding woman engineer graduating from UIUC this spring. The $100 award is named for a UIUC alumna and registered architect who was a member of the University's general engineering faculty from 1946 until retiring in 1973.

Professor **Roger A. Strehlow** of the Department of Aeronautical and Astronautical Engineering has been appointed to a three-year term on the National Materials Advisory Board.

The Department of Mechanical Engineering of the Naval Postgraduate School at Monterey, California, has announced the appointment of professor **Arthur P. Boresi**, UIUC Department of Theoretical and Applied Mechanics, to its first annual Research Chair Professorship.

An internationally famous computer scientist, **Donald E. Knuth**, will give the fourth annual Donald B. Gillies series of memorial lectures at UIUC during the week of September 17. Knuth is the Fletcher Jones Professor of Computer Science at Stanford University. The Gillies Lectureship is a memorial to **Donald B. Gillies**, a well-known computer scientist and member of the UIUC faculty for 19 years before his death in 1975.

George W. Conlee, a ceramic technician in the Department of Ceramic Engineering, has been honored with the Distinguished Service Award of Keramos, an annual award presented by the national ceramic engineering society. Conlee, who was made an honorary member of the UIUC chapter of Keramos several years ago, designs and fabricates high-temperature ceramic pots for research and teaching and also supervises high-temperature firing operations for the department's more than 40 kilns and furnaces. ●

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inside outlook:

HOW WHITE DWARFS PRODUCE X RAYS
IONOSPHERIC RESEARCH DURING A SOLAR ECLIPSE
COMPUTER GIFTS TO COLLEGE OF ENGINEERING
APPLYING THE MULTIPOROSITY THEORY TO THE PLACENTA
CONTINUING EDUCATION WITH ELECTRONIC BLACKBOARDS
HARD MATERIALS WORKSHOP AT UIUC
DEMAND FOR ENGINEERING GRADUATES AT ALL-TIME HIGH

THE INVISIBLE ENCORE

In Hollywood, a celebrity can be hot for awhile, but when the public loses interest the star slips into oblivion. In the universe, some of the longest running acts are white dwarfs, dying stars that have ended aeons of nuclear activity and have lost their ability to produce thermal energy. But research at the University of Illinois at Urbana-Champaign has revealed that some white dwarfs are not merely dead stars; instead they can produce rejuvenated radiation from temperatures more than 100,000 times the 6000 K temperature of our very active sun.

Present knowledge indicates that all stars with a mass less than about four solar masses are destined to become white dwarfs when the strength of nuclear activity pushing out from their cores can no longer balance the strength of gravity that constantly pulls matter towards their center. Eventually the nuclear energy will be exhausted, the balance of power will be in favor of the force of gravity, and the star's mass will be pulled inwardly to form a compact star with a diameter about 100 times smaller than it was before. For example, the average density of the sun is about 1.0 g/cm^3 (0.04 lb/in^3), but when it becomes a white dwarf, billions of years from now, the average density will be compacted by the force of gravity to about 10^6 g/cm^3 (18 tons/in^3).

White dwarfs are the least dense of the three kinds of compact stars which also include neutron stars and black holes. These latter two stellar objects are formed when a star with a mass more than about four times that of the sun explodes. When that happens, the outer layers of the massive star are blasted outwardly while the core of the star is compressed inwardly with such violent force that the matter reaches incredible density.

Matter inside neutron stars is in its densest possible finite state. For example, a neutron star with a mass equal to that of the sun would be about 20 km (12 mi) in diameter, because the average density would increase to about 5×10^{14} g/cm^3 (9×10^9 tons/in^3). If the matter were squeezed even more, it would result in a black hole where the fateful star's mass would be represented by a single compact point of infinite density and gravity so strong that absolutely nothing could escape from its grip.

Researchers at UIUC have concentrated their efforts on being able to identify some white dwarfs as x-ray sources in binary star systems, a phenomenon that happens only when a white dwarf has a companion star revolving around it. The white dwarf's intense force of gravity attracts atoms of hydrogen and helium that have escaped from the companion star and then fall with increased velocity the nearer they get to the dead star's surface. Since energy cannot be destroyed, the impact transforms the kinetic energy of the speeding atoms to thermal energy on the white dwarf's surface.

The constant accretion heats the surface to such a high temperature that its radiation is beyond the limits of visibility. If the sun, for example, were 1000 times hotter, we would be unable to see it because its radiation would surpass the spectrum of visible light. Since a white dwarf that is heated by accretion from a companion star is 100,000 times hotter than the sun, essentially all of the energy is emitted in the invisible spectrum of x rays and ultraviolet radiation. After an x-ray source has been detected by a satellite and its position has been accurately determined, optical observers focus telescopes on the same spot in the sky to find the visible normal star and confirm its role in a binary star system.

The x-ray research by professor D. Q. Lamb of the Department of Physics, and his graduate assistants, N. D. Kylafis, A. R. Masters, and G. J. Weast, has reshaped our understanding of these ancient stars. The Illinois research team has carried out detailed theoretical studies of x-ray and ultraviolet radiation emitted from the surface of white dwarfs and found that, contrary to previous belief, white dwarfs can produce x-ray spectra that match the ones observed by satellites. Furthermore, they have developed criteria for distinguishing between white dwarfs and neutron star x-ray sources.

In collaboration with x-ray observers at the University of California at Berkeley, Harvard University, and the Massachusetts Institute of Technology, UIUC researchers will attempt to uncover the nature of several x-ray sources and hope to be able to say which of them are white dwarfs. Comparison of theoretical calculations with observations made by satellites may enable them to determine the x-ray source's mass, magnetic field, and distance from the earth, quantities which were previously impossible to determine from x-ray observations alone.

Although the white dwarfs have ceased to radiate like normal stars, the UIUC research shows that accretion from companion stars can extend the white dwarfs' lifetimes by making them invisible sources of energy. Like show business stars switching from serious acting to comedy in order to gain a new generation of fans, the white dwarfs have found a new act. ●

A SHOT IN THE DARK

The February 26, 1979 eclipse of the sun was an occasion for three rockets carrying instruments from the UIUC Department of Electrical Engineering and the University of Bern, Switzerland, to gather information about the lower ionosphere.

A mobile unit of the National Aeronautics and Space Administration launched two rockets during the two-and-a-half-minute period when the eclipse was total at the site near Red Lake, Ontario. Two days before, the first of the three rockets was sent up from the same location to gather data under normal sunlight conditions that could be compared with conditions during the eclipse.

The Illinois researchers will analyze the information by computer to further the understanding of the electron production and destruction processes of the ionosphere. This phenomenon is particularly important in long-distance radio communications because the ionosphere is believed to absorb radio signals more during daylight hours. After dark, broadcast coverage areas increase due to radio wave reflection from the ionosphere. The eclipse provided an opportunity for controlled study of the ionosphere's loss of electrons when light and other radiation from the sun are shut off. At night this happens over a period of hours but it occurs in just minutes during an eclipse.

As one of the leading centers for ionospheric research, the UIUC Department of Electrical Engineering has received funding from NASA for 67 other rocket launchings since 1964 that have carried UIUC electrical instruments into the ionosphere. The department's research team at the eclipse study launch site included professor Leslie G. Smith, technician Norman D. Busboom, research engineer Lorenzo J. Johnson, and three graduate assistants. ●

GIFTS THAT COUNT

The Hewlett-Packard Company of Palo Alto, California, has given a $50,000 computer system to the UIUC Department of Electrical Engineering. In addition to another computer, three terminals, and three logic analyzers, the company's recent gifts to UIUC are valued at more than $130,000.

The computer firm hires fifteen to twenty graduates from the College of Engineering every year and now employs more engineering graduates from UIUC than from any other school outside California. ●

PRESSURES OF PREGNANCY

Blueprints and schematic diagrams are necessary engineering tools to guide the manufacture of complicated machinery. But for building the most complex of all machines, the human body, the engineering blueprint is, unfortunately, incomplete. To add further facts to our knowledge of the human body, a research project at the University of Illinois at Urbana-Champaign is applying engineering principles to humans at the fetal stage of development.

Professor E. C. Aifantis of the Department of Theoretical and Applied Mechanics has developed a mathematical model to determine the pressure distributions within the placenta, the organ shared by mother and unborn child which provides the fetus with nutrients and oxygen. When the mother's blood pressure is known, the mathematical model should be able to predict fetal blood pressure and other functions of the placenta.

The model is based on the multiporosity theory, developed by Aifantis to model the pressure distribution in multiporous media with several degrees of porosity. Since the placenta can be viewed as a double porosity medium, actually a mixture of three constituents: fetal blood, maternal blood, and placenta tissue, the basic law of mechanics and thermodynamics used in the multiporosity theory are applicable here.

The multiporosity theory can provide a rational approach for applying these principles to porous biological materials. The theory generalizes the single diffusion and flow theories normally associated with engineering materials and derives mathematical equations that show the relationships of several simultaneous diffusion processes. As examples, UIUC research has demonstrated mathematical equations which illustrate the relationships of the two different flow pressures in plants and the three different constituents of the placenta. Just as flow pressures in the cell walls of a plant differ from those in the larger xylem cylinders which bring nutrients up through the stem, blood pressure is stronger in the mother's body than in the fetus.

As applied to the placenta, the multiporosity theory takes into account the relationships of maternal blood pressure, fetal blood pressure and actions of the placenta tissue. Knowledge gained from the multiporosity theory could be used to generate a more specific model in the future that would involve several assumptions such as the geometric structure of the placenta, the type of materials involved, and how blood behaves as a fluid. Physicians already know what quantities of nutrients should be exchanged between the mother and fetus and, since the exchange depends on the pressure of blood, a better understanding of the multiporosity process in the placenta could enable doctors to regulate the growth of the fetus to ensure a healthy child.

The use of engineering principles, such as those of the multiporosity theory, have proven to be valuable definitions of bodily functions. This means of monitoring the growth of an unborn child seems a noteworthy contribution during the International Year of the Child. ●

FAR-TEACHING CHALK TALK

"Superstation" is the superlative used to describe TV stations that can be received on cable TV systems throughout the country by way of satellite transmission. "Superclass" may soon be the word for some engineering courses taught at the University of Illinois at Urbana-Champaign. Classroom voices and simulated chalkmarks are sent to and from electronic blackboards at several locations in Illinois via telephone.

The "superclass" is a means for the UIUC Office of Continuing Education and Public Service to offer educational programs to working professionals off-campus. The unique part of the electronic blackboard system, developed by Bell Labs and tested for the past three years at UIUC, is that students at remote locations can freely interact with students in the campus classroom or at other remote locations. To talk with people in any of the classrooms, each student has a conference telephone on his desk which allows him to participate as if all the locations were together in one room.

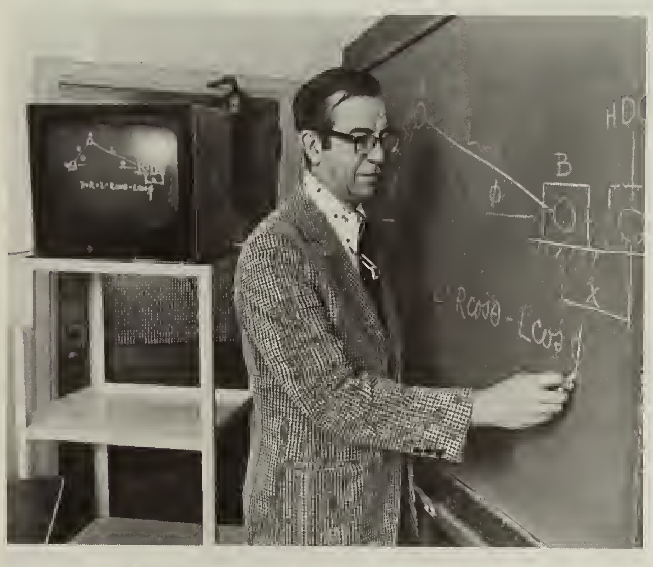
Although the student does not see the people to whom he is talking, he is able to view the complex engineering formulas that the instructor writes on a system of three blackboards at the Urbana-Champaign campus. For instance, to engage in two-way visual communication about a questionable calculation diagrammed on the blackboard, a student at a remote location can erase part of the formula, causing the erasure to be made simultaneously at all of the classrooms, and write an alteration on his blackboard. The professor can then make further illustrations on the blackboard to promote better understanding of the diagram.

The electronic blackboard is actually a normal-sized blackboard which senses the pressure made by chalk as it scratches over the surface of the board. Electronic impulses are transmitted to receiving monitors that simulate the path of the chalk's pressure. Since the transmission is made by voice-grade telephone lines, the expense is far less costly than two-way transmission of television pictures from several locations.

The system can be set up at any location served by telephone. In addition, tape recorders are available at all remote classroom centers and on-campus to enable students to tape the entire presentation, both voice and blackboard writing, on ordinary audio cassettes for later replay. This also allows students who miss a class session to observe what was discussed before the next class meets.

The electronic blackboard system enables UIUC to conduct live classes at remote locations without having to send an instructor. Previously, a minimum of 15 students have had to enroll in an off-campus course before the University could justify the expense and time involved of providing an instructor. With the new system, no minimum enrollment figure is needed because one student at a remote center could join the class without causing inconvenience for the University.

The electronic blackboards have made it possible for UIUC to offer more courses to off-campus students than ever before. Thus far, four remote centers have been set up for regular class sessions and more are planned. Now, a student who spends his time on the phone tapes good notes. ●



While a professor writes an engineering formula on an electronic blackboard on the Urbana-Champaign campus of the University of Illinois, monitors, like the screen shown at left, simulate the exact path of the chalk to enable students enrolled in continuing education courses at remote centers throughout Illinois to observe instruction and participate as if they were part of the class on campus.

HARD MATERIALS WORKSHOP

University researchers, industrial development engineers, and managers from throughout the United States will gather at the University of Illinois at Urbana-Champaign on June 28–30, 1979, to attend the 7th Hard Materials Workshop, supported in part by the National Science Foundation. This example of interaction between universities and industry is recognized as a display of the vitality of the U.S. technological enterprise.

A $65 registration fee for the three-day conference includes lodging at the Illini Union, social hour, and banquet charges. Interested persons are advised to register early to be assured a place in the workshop. Organization of the event is by the UIUC Department of Ceramic Engineering and the Office of Continuing Education and Public Service. ●

IN PURSUIT OF RECRUITS

The demand for engineering graduates from the University of Illinois at Urbana-Champaign has reached an all-time high, surpassing the record number of engineering job opportunities established in the 1960s.

Engineering graduates are being heavily recruited at universities across the nation. At UIUC, the greatest demand is for students with engineering majors in chemical, mechanical, industrial, and metallurgical engineering, while computer science has shown the fastest growing demand.

Last fall, 350 companies came to the UIUC campus and scheduled 9473 job interviews with students planning to graduate. The number of interviews was one-third more than a year ago and more than twice as many as three years ago. UIUC engineering degree candidates interviewed for job placements included 550 bachelor's degree candidates, 138 master's degree candidates, and 75 doctoral degree candidates.

The average salaries offered to bachelor's degree graduates from the UIUC College of Engineering was $1,434 a month. Graduates a year ago began work at salaries averaging $1,360 a month. Engineers who graduated from UIUC 10 years ago now average $2,247 a month, or 189% more than when they started their careers. Those who graduated five years ago now average $1,707 a month, up 85% from their entry-level salaries. ●

PEOPLE AND PLACES

Two UIUC faculty members have been elected to the National Academy of Engineering. UIUC now has 26 faculty members who have been elected to the academy. **Harry G. Drickamer**, professor of chemical engineering and a UIUC faculty member since 1946, was elected for contributions in the development of high pressure techniques and in the elucidation of new properties of solids and of diffusion in liquids. **Charles E. Taylor,** assistant dean of engineering and professor of theoretical and applied mechanics, was elected for pioneering developments in three-dimensional photoelasticity and in the use of lasers and holography in experimental machines. Taylor has been a member of the UIUC faculty since 1954. ●

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

COLLEGE OF ENGINEERING
VOL. 20, NO. 9, MAY 1979

inside outlook:

DETERMINING GRAVITY PLATFORM FOUNDATION RELIABILITY
PREDICTING THE EXTENT OF ARCTIC SEA ICE
GUSTAVE TRASENSTER MEDALIST FROM ILLINOIS
COLLEGE OF ENGINEERING HONOR AWARDS CONVOCATION

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OIL AND WATER DO MIX

Sailor stories tell of man's incessant struggle for survival on the high seas, the ferocious waves that test human endurance, and the tragic fates of the many who underestimate the awesome strength of the ocean. Motivated by the need to supply petroleum to an energy-hungry world, engineers have challenged the ocean's power by placing off-shore drilling rigs in the stormy North Sea. The probability of these man-made islands surviving against the unkind elements of the ocean had not been completely quantified until a research study at the University of Illinois at Urbana-Champaign was developed to analyze their foundations.

Professor W. H. Tang of the Department of Civil Engineering is determining the reliability of gravity platform foundations which support off-shore drilling rigs and dormitory complexes which are often six stories tall. Only 13 of these huge platforms, with surface areas measuring 80 m x 80 m (264 ft x 264 ft), have been built and all have become operational since 1973. Professor Tang is studying how the combined effects of ocean waves, weight, changing strengths of the sea bed soil, and other uncertainties can affect the safety of the platform foundation. The research does not attempt to analyze the reliability of the mechanical design variables inherent in the structure itself.

The gravity weight of the platform is more than 200,000 tons and causes constant stress on the sea bed soil anchoring the platform about 150 m (495 ft) below the surface of the water. The platform's three support cylinders are anchored by a concrete-steel skirt system which penetrates about 4 m (13.2 ft) into the ocean floor, but tilting can occur and cause instability if the soil structure loosens.

While gravity applies force from one direction, ocean waves are pushing against the structure from another. During storms, waves in the North Sea often reach about 23 m (75.9 ft) in height. Off-shore platforms have to be designed to withstand the pounding force of such waves, as well as waves up to 28 m (92.4 ft) which have the probability of occurring once every hundred years.

Most of the platforms are equipped with instruments which continually record the strength of the forces acting against the structures and also measure the motion of the platform. Computers at UIUC analyze these observed data to understand the behavior of the platforms during storms. Using this information, together with the data about statistical uncertainties of the natural forces and soil properties, the researchers may be able to estimate the probability of the foundation surviving against the strongest forces that could combine against it during the platform's anticipated lifetime.

With quantitative knowledge of soil strength and the forces caused by such uncertainties as earthquakes, the research information will help establish safety levels that future designs of off-shore gravity platforms must strive to achieve. Preliminary results of the research have found the platform foundations to be reasonably safe and have provided insight into design changes that could be more cost-effective. As the search for oil risks the fury of the ocean, research at UIUC is making the probability of survival a safer bet. ●

A NICE FORECAST

As temperatures become colder, one would expect the amounts of sea ice in the Arctic Ocean to increase. On the other hand, as more ice is formed, can one expect it to cause colder temperatures? This question and others have been answered by a University of Illinois at Urbana-Champaign research study which has resulted in several conclusions about the interactions between the atmosphere and ice from studying their offsetting effects on the Arctic Ocean over a 25-year period. The study's goals were to determine if the extent of arctic sea ice can be predicted when weather variables are known in advance, and also to determine if fluctuations in the extent of sea ice have an impact on large-scale weather.

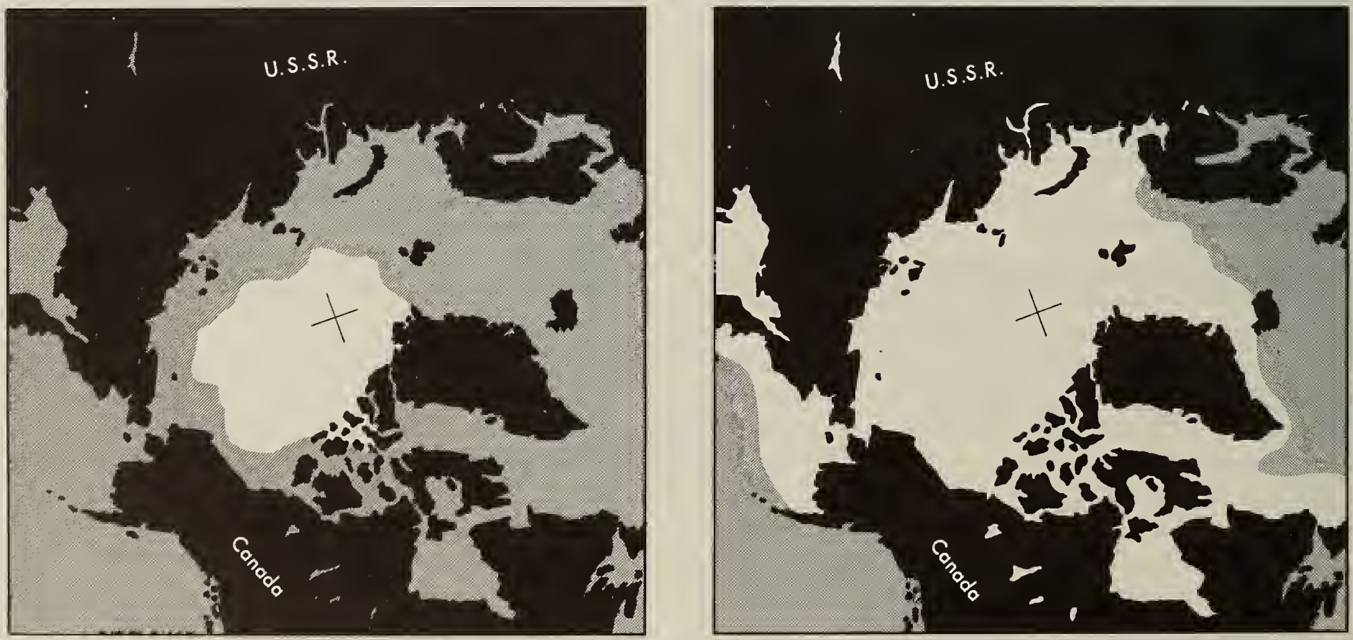
Led by professor John E. Walsh of the Atmospheric Research Laboratory, the UIUC project is the first study to include the entire arctic hemisphere in an evaluation of the relationships between atmospheric circulation and sea ice extent. Relying on the cooperation of several countries, the research team gathered meteorological data from various weather-monitoring sources, each covering separate regions of the Arctic during the 1953–1977 time period covered by the research. The data were synthesized by computer to graphically show ice extent and average temperatures for the entire Arctic in each of the 300 months studied.

When the average monthly surface temperature of the icecap was correlated with that month's total area covered by ice, it was revealed that the atmosphere has a greater effect on the ice than the ice has on the atmosphere. By statistical correlation, total ice area was shown to be significantly related to the cold temperatures that were recorded up to four months earlier. Meanwhile, ice effects on temperature did not correlate as strongly and showed a significant correlation for only two months.

In addition to surface temperatures, another useful predictor of ice extent is atmospheric winds, which are forceful enough to push the entire arctic icecap across the ocean until it becomes blocked by a land mass. The extent of arctic sea ice could probably be predicted fairly accurately from the UIUC data if not for the influence of a third contributing factor: ocean currents. Because the ocean currents' effects on the melt-and-freeze cycle of the arctic icecap cannot be quantified, meteorologists' predictions of sea ice extent are accurate only for periods up to four months into the future.

Another tendency illustrated by the 300 monthly icecap charts is that ice growth does not extend evenly from the center of the icecap. When ice growth is above normal in the Pacific side of the hemisphere, it is usually below normal in the Atlantic side and vice versa. This phenomenon is confirmed by the surface temperature data which show a tendency for the North American hemisphere to be warm when the Euro-Asian hemisphere is cold, and cold when the other hemisphere is warm.

The month-to-month variation in sea ice extent is illustrated by the 25 years of computer maps. Although the extent of sea ice can vary by several hundred miles for



The map on the left shows the minimum extent of arctic sea ice while the map on the right shows the maximum total area covered by ice during any of the 300 months between 1953 and 1977 studied in a UIUC research project. The icecap was smallest in the early 1960s when arctic temperatures were above normal; it covered the largest total area when the coldest temperatures of the 25-year time period were recorded in the late 1960s and early 1970s.

the same month in different years, February was usually the month when ice extended the farthest south and August the month when the arctic icecap was smallest.

A useful application of the knowledge gained from the Illinois study would be the ability to forecast which weeks arctic shipping lanes will be blocked with ice. In the past, many ships venturing into freezing water have been destroyed when trapped by sea ice formations. In the future, ships could be saved by long-range weather reports that include an ice forecast. ●

DEAN MAKES LIST

Daniel C. Drucker, Dean of the College of Engineering, has been selected as the 1979 Gustave Trasenster Medalist by the University of Liege, Belgium. He was honored for his work on the theory of plasticity and participation in the discovery of fundamental theorems in this field.

The award is the highest honor bestowed by the Belgian university's Engineering Alumni Association. Since the medal was first awarded in 1932, it has been received by such eminent engineers as Frederic and Irene Joliot-Curie, Enrico Fermi, S. Timoshenko, Th. von Karman, and V. K. Zvorykin. ●

HONORING EXCELLENCE

The 1979 Honor Awards Convocation for the UIUC College of Engineering was highlighted by distinguished service awards to six alumni, three faculty awards for teaching excellence, and awards to students. The Alumni Honor Award for Distinguished Service in Engineering is awarded to alumni or former staff members who have distinguished themselves by outstanding leadership in planning and direction of engineering work, by fostering professional development of young engineers, or by their contribution to knowledge in the field of engineering.

Receiving Alumni Honor Awards were Harry Czyzewski, founder and president of MEI-Charlton, Inc., Portland, Oregon; Jack L. Heckel, group vice-president of Aerojet-General Corporation, Sacramento, California; Milo Smith Ketchum, Jr., professor emeritus of civil engineering at the University of Connecticut, Storrs, Connecticut; Wen-Kwei Ku, chairman of Sinotech Engineering Consultants, Inc., Taipei, Taiwan; Robert C. Menken, vice-president of administration for the Winchester Group of Olin Corporation, New Haven, Connecticut; and Richard P. Wishner, corporate vice-president of Systems Control, Inc., Palo Alto, California.

Among awards presented to faculty members is the Everitt Award for Teaching Excellence. The award, named in honor of dean emeritus William L. Everitt, annually recognizes two or more engineering faculty members for their outstanding undergraduate teaching. This year's recipients were professor Robert W. Bohl of the Department of Metallurgy and Mining Engineering, and professor Michael J. Binder of the Department of Mechanical and Industrial Engineering.

Professor Wilbert F. Stoecker of the Department of Mechanical and Industrial Engineering received the Halliburton Engineering Education Leadership Award in recognition of demonstrated leadership of superior teaching that serves as a model of what to teach and how to teach. Outstanding service in college activities, effective commitment to the development of students and younger staff members, and national contributions to education are other accomplishments the Halliburton Award represents.

The Stanley H. Pierce Award, presented annually to an engineering student and faculty member who are selected as having done the most to develop empathetic student-faculty cooperation, was awarded to professor Richard O. Buckius of the Department of Mechanical and Industrial Engineering and to Bruce T. McCormick, a student in electrical engineering. The award is named in memory of Stanley H. Pierce, a former associate dean of the College of Engineering.

The Lisle Abbott Rose Memorial Award, which recognizes an outstanding senior student in engineering who most nearly approaches the ideal of technical excellence combined with cultural breadth, was presented to Barbara L. Edstrom, a student in general engineering.

The Honeywell Award, presented to reward distinguished individual performance and leadership by a junior in engineering, was given to Christine A. Berglund, agricultural engineering. The Harvey H. Jordan Award, which is based on high scholastic standing and character was presented to electrical engineering student Paul Gordon Baits. ●

VALUED RESEARCH

A survey by the American Society for Engineering Education shows that the University of Illinois at Urbana-Champaign accounted for 5.25% of the national total of $553,070,000 spent for engineering research in 1978 at the nation's 206 engineering schools and technical colleges. UIUC ranked second in the nation for separately budgeted funds with $21,056,000 for the College of Engineering. Only the Massachusetts Institute of Technology ranked higher, budgeting $25,483,000 for engineering research.

For combined separately budgeted research and engineering-related research outside the college, UIUC ranked third with $28,987,000. MIT was the leader, spending $67,341,000, and the University of California at Berkeley was second with $33,455,000. ●

GLASS PROBLEMS CONFERENCE

The 40th Conference on Glass Problems will be held November 13 and 14 at the University of Illinois at Urbana-Champaign. Topics for the 1979 meeting will include waste heat recovery, computerized control systems, raw material supplies, and melting and firing. The conference, which began in 1934, alternates between the University of Illinois at Urbana-Champaign and Ohio State University at Columbus. ●

PEOPLE AND PLACES

Professor emeritus **William W. Hay**, Department of Civil Engineering, received the highest honor of the American Railway Engineering Association when he was named an honorary member. The award has been conferred only 29 times since 1900 and only one other UIUC faculty member has received the honor: professor Arthur Newell Talbot, in 1933.

Professor **Arthur B. Chilton** of the Nuclear Engineering Program has been elected to a second six-year term on the National Council on Radiation Protection and Measurements. He is now on sabbatical leave and is completing work on a text in the field of radiation shielding.

Professor **Chester P. Siess**, retired head of the Department of Civil Engineering, has been named one of seven charter members of the Engineering Hall of Distinction at Louisiana State University. LSU cited him "for the eminence he acquired in the field of concrete-steel structures through his research, teaching, and professional activities."

The publishers and editors of *Engineering News-Record* have included professor emeritus **Nathan M. Newmark** of the Department of Civil Engineering among several individuals cited for having served the best interests of the construction industry for the past year. Newmark's contributions were noted for promoting new seismic building code provisions.

Professor **Shau-Jin Chang** of the Department of Physics has been invited to present a series of lectures at the International Summer Institute on Theoretical Physics in Kaiserslautern, West Germany, August 13–24, 1979.

Professor **Arthur J. Muehling**, Department of Agricultural Engineering, is one of four recipients of the Paul A. Funk Recognition Award for outstanding achievements and contributions to agriculture through teaching, research, extension education, and public service. ●

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